SCIENTIFIC AMERICAN SUPPLEMENT. No 1754

Entered at the Post Office of New York, N. Y., as Second Class Matter.
Copyright, 1909, by Munn & Co.
Published weekly by Munn & Co., Inc., at 361 Broadway, New York.
Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

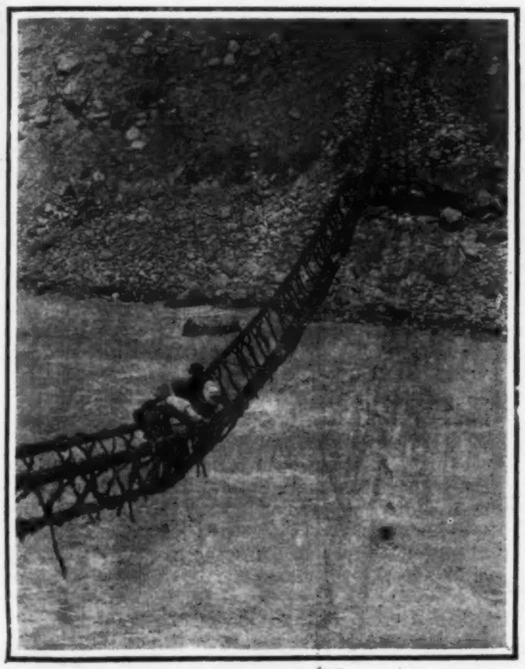
Scientific American, established 1845.
Scientific American Supplement, Vol. LXVIII., No. 1754.

NEW YORK, AUGUST 14, 1909.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE WORKMAN HIMALAYAN EXPEDITION.

THANKS to the speed of modern steamers and the development of the railway system in India, the base of the Himalayas is now only twenty days' journey



MRS. BULLOCK WORKMAN, A GUIDE, AND A BEARER CROSSING A MOUNTAIN STREAM ON A BRIDGE OF OSIER.

THE VILLAGE OF NAGAR IN CHINESE TURKESTAN.

WATERSHED PEAK.

MRS. BULLOCK WORKMAN AND HER COMPANIONS MADE THE ASCENT OF WATERSHED PEAK BY WALKING ALONG THIS NARROW SNOW-CLAD RIDGE.

from Mediterranean ports. Hence mountain climbers who wish to distinguish themselves by lofty ascents or explorations have undertaken summer expeditions in the high mountains of northern India. In the first rank of these pioneers are Dr. and Mrs. Bullock Workman, who since 1898 have made five expeditions in the Himalayas. Two years ago they ascended the highest peaks of the Cashmere and last summer they completely traversed this region which contains the greatest glaciers in the world, outside of the polar circle.

Watershed Peak. Mrs. Bullock Workman.

THE UPPER END OF THE HISPAR GLACIER AND THE RIDGE BETWEEN IT AND THE BIAFO.

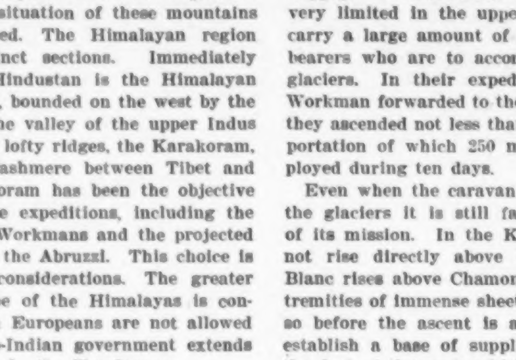
THE WORKMAN HIMALAYAN EXPEDITION.

Incited by the success of these explorers, three great expeditions, one of them led by the Duke of the Abruzzi, are preparing to start for this part of Asia.

What is the interest of these enterprises and what difficulties and dangers do they present? In what respect, in short, does Himalayism differ from Alpinism?

In the first place, the situation of these mountains must be briefly explained. The Himalayan region contains two quite distinct sections. Immediately north of the plains of Hindustan is the Himalayan district properly so called, bounded on the west by the Indus River. North of the valley of the upper Indus extends a second series of lofty ridges, the Karakoram, which covers southern Cashmere between Tibet and Afghanistan. The Karakoram has been the objective point of nearly all of the expeditions, including the five accomplished by the Workmans and the projected expedition of the Duke of the Abruzzi. This choice is determined by political considerations. The greater part of the southern slope of the Himalayas is contained in countries which Europeans are not allowed to enter, while the Anglo-Indian government extends every facility to explorers in the Karakoram.

The Himalaya and the Karakoram are the highest mountain ranges on the globe, and their principal peaks, Everest (29,000 feet) and Chagori (28,240 feet) are the loftiest mountain summits in the world. These giants are surrounded by many other peaks almost as high, including seventy-three between 24,000 and 28,000 feet, and a much greater number between 20,000 and 24,000 feet. The height of Mt. Everest is very nearly equal to the combined heights of Mont Blanc and the Jungfrau. The reader may be surprised by the omission of the famous Gaurisankar from this list of lofty peaks. It is omitted because it has been dethroned from its sovereignty as a result of the exact measurements made by the Indian geographical service a few years ago. It is now known that Everest and Gaurisankar are not one mountain as had long been believed, but two distinct peaks, and that the latter, the altitude of which is only 23,000 feet, must be relegated to the category of peaks of the sixth magnitude.



CARRYING A BEARER STRICKEN WITH VERTIGO OVER AN OSIER BRIDGE.

The Himalaya and the Karakoram furnish the most magnificent field for exploration that an Alpinist can desire. These ranges are still to a great extent unexplored, so that the traveler, according to his taste, may choose scientific exploration or sport, the making of maps, the ascent of untrodden peaks, or the making of a record in altitude. But these expeditions are extremely laborious. A tedious voyage of more than six weeks is required to reach the glaciers of the Karakoram. From Bombay, the port of disembarkation, it is a railway journey of three days and three nights to the foot of the Himalayas, at Rawal Pindi; thence the journey is continued in wretched back-breaking carts for more than 200 miles to Srinagar, the capital of Cashmere, a sort of Himalayan Interlaken. The subsequent journey includes from twenty to thirty stages across passes as high as Mont Blanc and through scorching valleys. In one of the gorges Dr. Workman noted a temperature of 212 deg. F. by the blackened thermometer. In the course of this preliminary march the traveler has many opportunities to exhibit his acrobatic talents. In this region the bridges are dizzy affairs which should not be attempted by any one who is not absolutely steady and sure-footed. The slightest misstep would mean death. The bridge consists of three osier cables connected with each other at intervals by ropes. The lowermost cable, as broad as the two hands, constitutes the footway and the other cables serve as hand rails. This frail bridge swings to and fro in the wind and its middle part is often washed by the waters of the torrent. At intervals of twenty-five or thirty paces a transverse piece of wood extends between the two upper cables at a distance of a yard or so above the footway. It is necessary to clamber either over or under these obstacles, an operation which cannot always be performed without a shudder, according to the hardy Alpinist, Dr. Jacot-Guillarmod.

The preliminary journey to the foot-hills is retarded by the fact that the traveler is forced to take with him a caravan of from 100 to 200 or more bearers. In the Himalayas the European traveler must carry everything required for his subsistence, including tents, sleeping bags, culinary utensils, and large quantities of tinned foods; in all, two or three tons of baggage. Furthermore, as the food supply is often very limited in the upper valleys, it is necessary to carry a large amount of food for those of the native bearers who are to accompany the traveler over the glaciers. In their expedition of 1906 Dr. and Mrs. Workman forwarded to the foot of the mountain which they ascended not less than 7 tons of rice, in the transportation of which 250 men and 60 ponies were employed during ten days.

Even when the caravan has arrived within sight of the glaciers it is still far from the accomplishment of its mission. In the Karakoram the mountains do not rise directly above inhabited valleys, as Mont Blanc rises above Chamonix, but are found at the extremities of immense sheets of ice 25 to 30 miles long, so before the ascent is attempted it is necessary to establish a base of supplies on the glacier itself, at the foot of the peak which is to be climbed. In this work numbers of coolies heavily laden are kept journeying to and fro for weeks, for it must be remembered that it is necessary to bring everything, not only tents and food, but even wood and alcohol for use as fuel in the preparation of the hot foods which are absolutely necessary at these altitudes. These bases of supplies are usually established at heights between 13,000 and 15,000 feet. Beyond them the advance is made by stages, with the establishment of a series of camps and of depots of provisions extending to the summit. In the ascent of a peak of 23,000 feet in the western Himalayas Dr. and Mrs. Workman encamped in four different places between the altitudes of 17,000 and 21,000 feet. The expedition to Chogori, of which Dr. Jacot-Guillarmod was a member, established not less than 12 camps before reaching a height of 21,000 feet, and it remained 55 days above 11,650 feet. In these altitudes the nights were extremely cold. Temperatures below zero Fahrenheit are not uncommon in August, and the travelers lose appetite and are unable to sleep.

According to Dr. Jacot-Guillarmod the tinned food and the low temperature are responsible for the progressive debility, which increases with the length of the sojourn in these upper regions. In an organism thus weakened the rarefaction of the mountain air causes labored respiration and frequent attacks of vertigo. It is a remarkable fact that the native bearers are most affected by the mountain sickness. Often attacks of asphyxia, profuse bleeding at the nose, and persistent nausea make the poor wretches unable to move. In these conditions it is impossible for the expedition to ascend higher. This is the sole reason why no greater height than 23,600 feet has yet been attained. The few explorers who have reached this altitude experienced only slight indisposition, and if they had had bearers immune to mountain sickness they could possibly have gone 2,000 or 3,000 feet higher. The conquest of the highest mountain summits of the globe, like that of the South Pole, appears to be a simple question of transportation of supplies.

The last expedition of Dr. and Mrs. Workman was undertaken, not in order to surpass the record of altitude, but to explore the two great glaciers of Hispar and Biafo, situated in the extreme north of Cashmere, near the Tibetan frontier.

In the Karakoram, glaciation has acquired a development which is extremely remarkable in view of the comparatively low latitude. Although it has the same latitude as the Straits of Gibraltar, this mountain range includes the largest glaciers of the world outside of Alaska and the Polar regions. There are numerous sheets of ice from 30 to 43 miles long, almost thrice as large as the Aletsch, the largest of the Alpine glaciers. The Hispar and Biafo glaciers are joined at their upper ends and form a continuous band of ice about 62 miles long which is the largest glacier formation in existence in the temperate zone. The presence of such masses of ice in this latitude is evidently due to the copious precipitation caused by the monsoons. Glaciers, indeed, are fed by humidity rather than by cold.

In order to reach the Hispar glacier the Workmans proceeded from Srinagar to Nagar at the foot of the mountain chain which separates the three great Asiatic empires of India, China, and Russia. Thence pursuing their march they arrived in 25 days at the foot of the glacier. The Hispar forms a sea of ice from 30 to 37 miles long fed by great tributaries as large as the greatest glaciers of Switzerland. All these frozen roads are extremely hazardous, as they are intersected by wide crevasses and by heaps of those unstable blocks of ice which Alpinists call *séracs* and which in falling are liable to crush the traveler, while along the sides of the glacier extend steep snow-covered cliffs from which avalanches are incessantly falling. Under some of these cliffs there is a never ceasing shower of ice and snow. In these conditions the transport of provisions is extremely difficult. More than 200 coolies were constantly traveling with supplies which nevertheless often fell short. The natives, who have no taste for mountain climbing and were terrified by the perils of the glaciers, sometimes refused to advance, and "struck" like the artisans of civilized countries. From this fact Mrs. Bullock Workman concludes that the principle of the strike is inborn in man, since a Cashmere coolie who has never had any relations with the external world instinctively uses this method of coercing his employer.

By dint of patience and industry the explorers triumphed over all difficulties and arrived, after a four weeks' march, at the upper end of the Hispar, a vast snow-clad plain surrounded by majestic peaks, an imposing symphony in white major, as Theophile Gautier once described Mont Blanc. On the mountain ridge which separates the Hispar from the glacier of Biafo rises a steep peak 21,000 feet high. In spite of unprecedented difficulties Mrs. Bullock Workman ascended this peak, to which she gave the name of Watershed Peak. At a height of 2,000 feet she was compelled to walk along a narrow ridge about 20 inches wide between two deep chasms. After this exploit the caravan crossed a pass and then descended the Biafo glacier, a band of ice some 25 miles long. Not until the end of August did the intrepid explorers return to *terra firma*, after 56 days of travel on the ice. This expedition is not only a remarkable exploit in mountain climbing but, owing to the collaboration of two young students of the University of Fribourg, Switzerland, it accomplished important scientific results, including an exact map of the Hispar glacier and numerous observations of very great interest and value. East of the Biafo glacier, which was crossed by the American expedition, is an equally large river of ice, the Baltoro, from which rises Mount Chogori, the culminating point of the Karakoram, and the second highest mountain peak on the globe. This is the mountain which the Duke of the Abruzzi has undertaken to ascend. The Italian prince has taken with him a troop of hardy Alpine guides, and with the assistance of these experienced mountaineers he should be able to establish camps at heights which former explorers have not been able to attain with their recalcitrant and apathetic coolies. Hence if the weather conditions are favorable this royal explorer is likely to succeed in his enterprise and win for Italy the record of altitude of mountain climbing.—Translated for the Scientific American Supplement from L'Illustration.

DEFINITION OF HEAD OF WATER.

In a recent paper Charles T. Main, mill engineer and architect, of Boston, gives the following definition of "head" as applied in water power development, as follows:

There is the "legal head," or the head to which the owner has a right to develop his power. This may or may not have been developed to its full extent. It may be that the expense involved would be too great to warrant further development. In some cases it may be economy to make the expenditure necessary to get the benefit of some unused portion of the head.

The "gross head" is the head actually used for producing power and getting the water to and away from the wheel.

The "net effective head" is the gross head minus the loss in head required to get the water to and away from the wheel. This loss will vary with the length of the waterways leading to and away from the wheels, the velocity of the flowing water, and the construction of such waterways.

In several manufacturing cities where the water power is controlled by a company which is separate from the mill owners, there is an allowance of one foot made from the gross head before charging for the water as used on the wheels.

The head should be measured with the wheels running. The only portion of the head which produces power is the difference in level directly above and below the wheel when the wheel is running.—Electrical Review and Western Electrician.

SNAIL GARDENS.

A CURIOUS FRENCH INDUSTRY.

BY D. GEYER.

For many years the sale of edible snails was a peculiarity of the market of Ulm in the Swabian Alps. The snails were collected in the neighboring forests, and cultivated in specially arranged snail gardens. After the snails had retired into and capped their shells for their winter sleep they were brought to the city, whence they were carried down the Danube in boats to Vienna, where they were highly esteemed as a Lenten delicacy. The decay and ultimate extinction of cheap transportation by water greatly diminished and for a time threatened to annihilate the trade in snails, but in the past decade a new market has been found in France, and Ulm remains one of the principal centers of this peculiar industry. The field of collection now embraces the entire Swabian Jura and many parts of Württemberg and Baden, and new depots have been established in Gutenstein and other towns, while the villages of the Lauter and Danube valleys possess many snail gardens, each containing from 50,000 to nearly a million snails. In the summer of 1908 the gardens of Gutenstein alone harbored three of four million snails.

In the latter part of June men, women and children begin collecting snails and placing them in temporary pens, whence they are taken, in boxes, baskets and open wagons, to the large snail gardens. Many are killed by improper handling, for the well nourished, juicy and active snails suffer greatly from close confinement. If they are kept in cellars to save the expense of outdoor pens they are attacked by disease which causes their death after they have been installed in the gardens. Hence the snail farmers refuse to purchase snails with foul shells, which give evidence of long confinement in unsuitable conditions. The snail garden is usually laid out on a hillside and is surrounded by a low fence of wire netting of large mesh, which does not give sufficient surface for the snails to adhere to, climb over and escape. Snails easily climb a board fence, and tar or other acrid substances smeared on the boards kills the snails, while a border of sawdust or sand, inside the fence, soon becomes damp and covered with the mucous secretion of the snails, and then ceases to present an obstacle.

The surface of the inclosure is strewn with moss, in which the snails burrow in cold weather and in drought. In order to allow the gardens to be visited, the moss is arranged in beds, separated by paths, and the food is laid on it. In wet weather moss and remnants of food sometimes putrefy and injure the health of the snails. Careful snail farmers lay narrow plank bridges over the moss which protect it from rain and allow the garden to be traversed with out danger of treading on the snails. Some farmers make imitation bushes by planting branches and twigs, or arrange loose heaps of brush to form dry and airy shelters.

There is little evidence of scientific culture adapted to the needs of the animals. This is admitted by intelligent cultivators who have learned from their losses. All the cultivators are beginners, who have only a few years' experience, and their chief aim is to feed their captives as cheaply as possible. On a mountain side with little grass and no shade and no supply of water, even by sprinkling, the snails are exposed to every vicissitude of the weather, and the overcrowding of the gardens is very unfavorable to the health of their inmates. At the least, the gardens should be arranged like sheep folds, so that the snails could be moved at intervals, instead of remaining for months in the same inclosure, foul with putrid food, moss and excrement.

A still more serious error is committed in regard to the season of capture. Formerly this began in August, but competition has advanced its commencement to the last week in June, at which time few of the snails have laid their eggs. The result is that the snail gardens are often covered with white eggs, as big as peas, all of which are wasted because no provision is made for hatching them. An industry conducted in this way is self-annihilating. The snail farmers are aware of the danger of its extinction, and a few officials in Baden and Württemberg have established protective regulations, but there is no uniform and thorough legal control of the whole district. The main question concerns the proper time for opening the hunting season. Deferring the date until August 1st would give complete protection to the young brood, but would probably diminish the profits of the snail farmers, as it would limit the hunting season to about four weeks of hot, dry weather, in which the snails seek shelter and are hard to find. The 15th of July should be a compromise satisfactory to both sides.

The snail gardens, in spite of their obvious defects, are very interesting, as they exhibit, in small compass, the great variety of forms assumed by this single species (*Helix pomatia L.*) in southwestern Württemberg and the adjoining districts of Baden. But the variations caused by differences of soil and geological formation are less striking than the individual variations. The snails vary in height from 1¼ to 2¾ inches, and in color from white to dark brown, through all intermediate shades, with and without stripes. The life history of every snail is written on its shell. One has led a peaceful existence under a bush beside a brook, another has lived on a barren, sunny rock, a third has been unable to get rid of all of last winter's mouth covering and has incorporated the remnant in the new growth of shell, a fourth has been born a pervert, so that its shell turns to the left instead of to the right, as it should. Some have sustained injuries to shell or body and repaired them as well as they could. An injury to the shell-excreting organ produces a long scar, which persists through life, and rupture of the ligament which connects shell and body causes the formation of a pointed, nearly cylindrical shell, resembling a winding stair.

Very misleading results have been obtained in experiments made with newly captured snails for the purpose of testing the acuteness of their senses and their "mental capacity." One experimenter placed twelve snails in a circle around a head of cabbage and, finding that only one of the animals went to the cabbage, while the others moved in various directions, concluded that snails are dull of sense. This inference was entirely unwarranted. The first impulse of every animal which has been suddenly transported to a new and strange environment is to escape. Freedom is more enticing than food, and fear is more powerful than hunger. The most appetizing aroma of cabbage could not stay the flight of the frightened captives. If the experimenter, placed in similar conditions, had stopped to eat he would have been more stupid than the snails.

Observations made in snail gardens prove that snails, like all other animals, are sufficiently sharp of sense to find their food. Fresh lettuce, laid on the moss in the midst of a throng of snails, which are apparently crawling about aimlessly but are really seeking food, is promptly surrounded by a ring of snails hastening toward it from every direction. Snails eat with the aid of a ribbon-shaped organ called the tongue, which is set with fine, sharp teeth and is used like a rasp. A loud rustling and crackling noise is heard when thousands of snails are feeding together. In the gardens they are fed, preferably, with lettuce and endive, which are grown on a large scale for this purpose, cabbage and dandelion leaves and chopped kohlrabi. In the absence of these favorite foods nettles, clover, and potatoes may be substituted. Clover is eaten with reluctance and the skins of potatoes are rejected, but nettles, among which snails of all species congregate in a state of nature, are greedily devoured. Nettles are also a favorite food of young geese. Last summer, when the cabbage crop was destroyed by insects and the crop of fruit was very large, windfall fruit was fed to the snails which, like children, appreciated it in proportion to its sweetness. Snails are as fond of young kohlrabi leaves as horses and cattle are of clover, and in both cases overeating causes illness and death by the distension, sometimes even the rupture, of the stomach by the gases produced by fermentation. In one large snail garden wheat bran has been fed.

Constant care is required to prevent the escape of the snails which collect beside the low fence in heaps as high as the fence itself. Snails are proverbially slow of movement, but they can travel more than fifty yards in a warm, rainy night, so that the snail farmer must rise at dawn, or earlier, to recapture the fugitives. It is an open question whether escaping snails aim for a definite goal or not. Most of the fugitives travel uphill, toward the forest, or with the wind, but other snails escaping from the same garden pursue an opposite course. Many snail farmers firmly believe that snails have some means of determining the direction of a neighboring forest, but this appears to be disproved by the experience of other districts. Snails certainly cannot see the forest, but they may perhaps be informed of its proximity by the humidity and peculiar odor of the air.

The eyes of the snail are carried on long extensible stalks, which are instantly retracted on the approach of any object. A man walking slowly beside a snail garden is accompanied by a wave of retraction in the myriad eyes within the inclosure, each of which is again protruded the instant he passes out of its field of view.

Even when the fence is high enough to make escape impossible the habit of the snails to collect in masses beside it prevents eating and free respiration, overheats the animals and causes them to be soiled and poisoned by their excretions, so that the snails at the bottom of the heap may be killed in a short time. Hence it is necessary to redistribute the snails uniformly over the garden at frequent intervals. This operation brings other dangers. Incomplete and soft shells are broken at the edge, necessitating repairs which retard the process of growth. If the injury is extensive, dry or very wet weather or parasites may kill the snail before the hole can be stopped by secreting new shell or patching together the fragments of the old shell.

A snail may even be killed by being overturned so that it lies on its back, for the animal cannot right itself without a long and severe struggle, with its body protruded to the utmost extent, and in the course of the operation it may be drowned by rain or parched by the sun. The soft body of the snail is exceedingly sensitive to atmospheric influences. Snails are most active in warm and rainy weather. In periods of drought they bury themselves in the moss, coming out to feed only during the night and early morning. In consequence of this habit and the protection afforded by their shells and slimy secretions very few snails are killed by drought.

The only possible protection against cold is a warm shelter on or beneath the surface of the ground. But it takes time to reach such a shelter, and in autumn the slow-moving creatures are often overtaken by sudden cold. This is always injurious, and many snails are killed by repeated sudden changes of temperature. If frost is expected, the snails should be covered with straw or blankets, as a single cold night may be fatal to thousands. They are not killed outright, but they become ill, refuse to eat, and die within a few days.

Preparation for the winter sleep is commenced between the 1st and the 15th of September, and by the end of October all the snails lie buried in the moss. In the free state they burrow underground, but in captivity this is prevented by providing them with moss and selecting hard, stony ground for the snail garden. When a snail seeks the shelter of the moss bed in summer it remains in its normal crawling position, with the mouth of the snell directed downward, but in the winter sleep the animal lies on its back with the mouth of the shell directed upward. This opening, however, is now covered by a series of transparent membranes and a thick, white calcareous plate, formed during the weeks of preparation.

It is in this condition and in the winter season that the snails are sent to market. Individuals which have hibernated early may be tempted by warm weather to throw off their mouth covers and crawl about as if spring had come. When they are compelled by ensuing cold weather to cover themselves again they are unable to secrete a second plate of shell, although they succeed in producing a glasslike membrane. These "glass snails," as they are called, seldom survive the winter. Other snails, called "runners," fail to secrete any winter covering and share the fate of the glass snails.

The marketing season opens on November 1st. The snails are sold either by weight or by the thousand and are sent chiefly to Paris.

The great French demand for snails has led to the invention of imitations. The snail farmers collect the empty shells that have accumulated during the summer, wash them and sell them for about 25 cents per thousand. The shells are sent to Paris, where they are filled with a mixture of snail flesh, liver, butter and herbs.—Translated for the Scientific American Supplement from Kosmos.

Something like a record has been made in the life of accumulators in the case of an accumulator fitted to a car supplied seven years ago. A report is to hand, states the Autocar, to the effect that the car is still in daily use, although it has covered over 86,000 to 90,000 miles, and nothing whatever has been done to the accumulator beyond charging it.

SOME NEW BACTERIOLOGICAL DISCOVERIES.

INHERITANCE OF ACQUIRED CHARACTERS IN BACTERIA.

BY DR. REINER MUELLER.

Bacteria have often been observed to form varieties distinguished by differences in pigmentation or in the power to produce disease. In nearly all cases the change was a loss or diminution of normal characters. Degenerative changes of this nature possess far less scientific interest than the appearance of new and thenceforth hereditary characters.

Three years ago Massini studied, in the Ehrlich Institute in Frankfort, a bacterial intestinal parasite which in certain conditions acquires the new property of producing lactase, the enzyme which decomposes milk sugar. A second bacterium which exhibits the same peculiarity was described by Burk two years ago, and three others have been discovered by the writer. The production of lactase is brought about, not through a series of intermediate stages, but suddenly and completely without any gradation. Hence Massini regards the change as a mutation in the sense given to that word by Hugo de Vries.

The accompanying photographs illustrate the changes as they appear to the naked eye. Fig. 1 shows a colony of one of the bacteria investigated by the writer, after 14 days' cultivation on the surface of a medium containing one per cent of milk sugar. On culture media free from milk sugar this bacterium forms flat, smooth colonies, but when milk sugar is present it begins, after a day or two, to produce knob-like elevations. These knobs are composed of bacteria which have acquired the power to produce lactic acid fermentation in milk sugar, a property which is not shared by the other bacteria of the colony. This fact can be detected with the naked eye by means of a culture medium, devised by the Japanese investigator Endo, which contains agar, milk sugar, and fuchsin decolorized by the addition of sodium sulphite. When the bacterium is cultivated on this medium the lactic acid produced by the altered bacteria restores the color of the dye and the knobs appear dark red in the otherwise colorless culture. Fig. 2 shows such a culture with its dark red and its pale and unaltered groups of bacteria. The culture is started by pricking the culture shown in Fig. 1 with a needle, at the edge of one of the clumps of altered bacteria. Both altered and unaltered bacteria adhere to the needle and are thus transferred to the Endo culture medium, which in 24 hours after the infected needle is drawn through it, presents the appearance shown in Fig. 2. The pale colonies again produce knobs of altered bacteria, but the red colonies, consisting of altered bacteria, do not form knobs.

This very remarkable phenomenon may be regarded as follows: These bacteria multiply very rapidly, each individual dividing into two in less than one hour, and producing in twenty-four hours a colony several millimeters in diameter, which contains millions of bacteria. Hence the usual food of the bacteria, if not very abundant, is soon exhausted. In this juncture it appears as if one of the bacteria suddenly discovered the nutritive properties of the hitherto untouched milk sugar. This inspired bacterium multiplies more rapidly than the rest, as the elevation of its colony in the form of a knob proves, and it transmits the new character to all its descendants, which retain it during years of culture on media free from milk sugar.

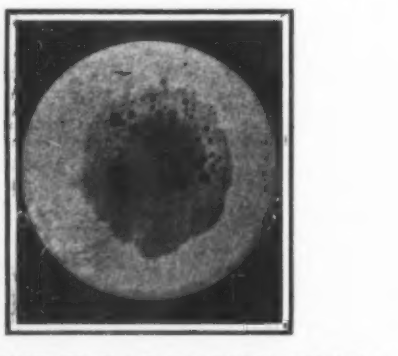


Fig. 1.—MUTATION OF BACTERIA INDUCED BY MILK SUGAR.

I found that this mutation is not manifested only by the formation of knobs on semi-solid culture media but that it takes place in some of the bacteria of cultures in milk and other liquids containing milk sugar.

After the discovery of this remarkable mutation in a few races of bacteria I undertook a systematic search for analogous mutations, cultivating hundreds of kinds of bacteria in media containing 18 sugars and other carbohydrates. I found many bacteria which developed the characteristic knobs in presence of one or another of these substances, erythrite, arabinose, dulcite, adonite, saccharose, etc., but very few bacteria which were thus affected by more than one compound.

Especial interest attaches to the bacteria of disease. Fig. 3 shows a colony of typhoid bacilli after four days' growth on agar containing one per cent of isodulcite. I found that every culture of typhoid bacilli formed the characteristic knobs on media containing isodulcite and that the altered bacteria constituting the knobs grew still more rapidly, but formed no new knobs, when they were transferred to a new isodulcite medium. But the altered bacilli resembled normal typhoid germs in all other characters, including the power to cause typhoid in animals, and the phenomena of agglutination, which form so valuable a bacteriological test. With the paratyphoid bacteria discovered by Schottmueller, the corresponding mutation and formation of knobs are induced by a different substance, raffinose.

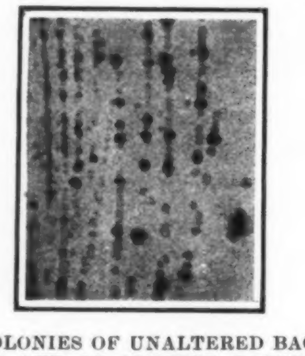


Fig. 2.—COLONIES OF UNALTERED BACTERIA (PALE) AND OF ALTERED BACTERIA (STAINED RED).

These phenomena show a striking resemblance to the development of cancer. In both cases some members of an aging congregation of similar cells suddenly burst through the bounds which have previously limited their capacity for multiplication.

The phenomena are of interest to workers in various fields of science: to chemists, for here definite species of bacteria appear as reagents for the detection of definite carbohydrates; to physiologists, for here enzymes of fermentation are produced under the influence of the substance which is to undergo fermentation; to physicians, for they afford means of distinguishing the germs of various diseases (as those of typhoid by isodulcite and those of paratyphoid by raffinose) from each other and from other very similar bacteria.

To the biologist, however, the fact of transcendent importance is the demonstrated possibility of impressing upon a living organism, by artificial means and with the certainty of a chemical reaction, a new and definite character, which is thenceforth hereditary and remains constant through a vast and indefinite number of generations.—Translated for the Scientific American Supplement from Umschau.

CAN ANIMALS PREDICT EARTHQUAKES?

"From the earthquake district in Sicily and Calabria, where seismic disturbance is still frequent, though slight, comes the news," says a recent number of Corriere della Sera, "that also this time, before the catastrophe, animals began to predict through signs of unrest the approaching earthquake. This observation must be added to a long series of similar manifestations. It is related of the earthquake that destroyed Elike, in the year 373 B. C., that its approach drove many animals—mice, moles, weasels, and serpents that nested under the earth, to the surface already five whole days before the catastrophe and caused them to remain there for a long time. Shortly before the earthquake that raged in Sicily in the year 1783 animals came to the surface, as well as various creatures of the sea, especially fish in stupendous numbers, among them also such as are found only in the greatest depths of the water.

"Domestic animals seem to be especially susceptible to the approach of earthquake. In the year 1825, for instance, in Talcahuano, Chili, every dog fled from the city before the inhabitants perceived the faintest hint of the imminence of the disaster that overwhelmed them. In Java, in 1867, immediately before the earthquake every rooster began to crow shrilly and left the scene of the disaster which soon thereafter shook the doomed town into a heap of ruins. In 1887 the Riviera was menaced by an earthquake, and of this instance it was told that horses in their stalls gave keen signs of anxiety over the imminence of the visitation. The terrific disaster that swooped upon the city of Iquique in the year 1868 was announced many hours previously by screaming gulls and other sea-birds that flew in great swarms far into the inland; and quite recently two further instances of this kind have appeared. In April of the year 1905 the inhabitants of Lahore found it impossible to explain the sudden remarkable conduct of the elephants, until some hours later a sturdy earthquake gave a sufficient explanation of their extraordinary unrest; and the other instance was afforded by the earthquake at Karatagh in October, 1907, which was announced simultaneously by dogs, cattle, and horses. It is not permissible, by the way, to declare these observations false because they were not made chiefly by exact professors of natural science, for the observation made by Humboldt on the Orinoco, that the crocodiles leave the waters of the river invariably on the imminence of earthquake, suffices to attest the correctness of the observations made by numerous others.

"But what is the basis of this remarkable instinct of animals, reptiles, birds, and fish? Electrical phenomena of some kind, to which these creatures seem to be especially susceptible, are held by many observers to be responsible for their very early perception of imminence in such instances. There are others again who attribute to these creatures an unknown sixth sense, in its way as enigmatic as the sense of locality in many animals. More enlightenment, however, is afforded by the explanation that it is their sense of hearing or their sensibility to agitation that enables animals to notice the effect of the occurrences in the interior of the earth long before mankind with its coarser senses can perceive it. But in this case the objection would certainly arise that the delicacy of the animal senses exceeds that of the finest seismographic apparatus. To our initial question, therefore, must be given the answer that animals can foresee earthquakes with a probability that approaches certainty, but that by no means have we yet a satisfactory explanation of their superiority to mankind in this respect."

Greasing Media for Wool That Is to Be Spun.—*a.* 2.8 parts of olive oil, 7.5 parts of water, 0.25 part of soda. (According to Lord.) *b.* 4 parts of oil, 2 parts of spirits of sal-ammoniac, and 1 part of water are boiled by steam until the smell of ammonia has disappeared. (According to Mottel.) *c.* 15 parts of olive or rape seed oil, 1 part of ammonia, 15 to 20 parts of water. (According to Gedge.) *d.* 100 parts of hard soap, 50 parts of glue, 15 parts of soda. (According to Delmasse.) *e.* 87 parts of soft water, 10 parts of white soap, 24 parts of oil, worked into an emulsion. (According to Karmarsch.) *f.* 3 parts of wool-washing water, 2 parts of sulphuric acid. The fat separated is heated with 5 per cent of hydrochloric acid and finally 5 per cent of oil or petroleum added. (According to Lepainteur.)

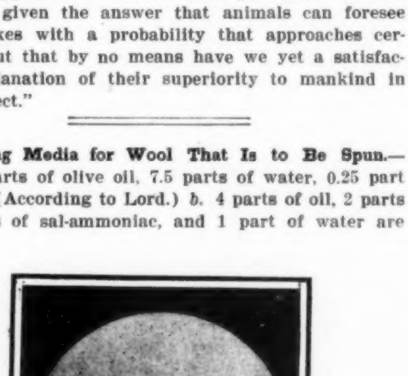


Fig. 3.—MUTATION OF TYPHOID BACILLI INDUCED BY ISODULCITE.

THE FORM AND DIMENSIONS OF THE EARTH.

MEASURING OUR PLANET'S GIRTH.

BY DR. GIVET OF THE FRENCH EQUATORIAL GEODETIC EXPEDITION.

An approximately correct idea of the form of our planet is a recent acquisition of science. For centuries human vanity befogged with complicated hypotheses the admirable simplicity of the laws which govern the universe, assigning to the earth, as it assigned to man, a privileged and unique place in nature.

The astronomers were the first to protest against this arrogant assumption. In 1513, long before the zoologists had removed man from his "splendid isolation" and returned him to his proper place among living creatures, Copernicus pointed out the low rank of the earth in the hierarchy of the heavenly bodies. This fertile discovery soon gave birth to a new science, geodesy, the study of the form and dimensions of the earth, which was destined to experience a marvelous development in the course of the following three centuries. Although the methods and operations of geodesy are exceedingly intricate, its fundamental principles are simple and easily comprehended. If the earth were perfectly spherical it is evident that all arcs of great circles comprising the same number of degrees would have the same length in miles or feet, no matter what the positions of the planes of the circles. Hence the diameter of the earth could be computed from the length of any arc of one degree.

But the problem is not so simple as this. The intersection of the earth's surface with a plane which passes through its poles is not a circle, but an ellipse. In other words, the earth is not a sphere, but an ellipsoid of revolution. Until the beginning of the 18th century, geometers discussed the question whether this ellipsoid was elongated or flattened in the line of the polar axis. Research finally proved that it is flattened, as Newton had asserted. This flattening, or

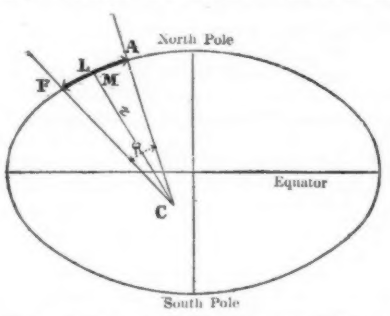


Fig. 1.—OBLATENESS AND RADIUS OF CURVATURE.

oblateness, of the earth is now so well known that it appears almost axiomatic, but the establishment of this fact required half a century of discussion and research.

The principle of these researches is illustrated by Fig. 1. A very short arc, AF, of an ellipse may be regarded as an arc of a circle, whose center C is determined by the intersection of the normals, AC and FC, drawn to the curve at the extremities of the arc. Knowing the length, L, of this arc and its amplitude in degrees, φ, it is easy to calculate the length of an arc of one degree in the part of the ellipse under consideration, and, consequently, the length of the radius, r, of the circle to which the arc may be regarded as belonging. This length is called the radius of curvature of the ellipse at the point under consideration.

In an ellipse the radius of curvature increases as the point considered moves from the extremity of the major axis to the extremity of the minor axis, and the length of an arc of one degree increases proportionally. Hence, by measuring the lengths and angular amplitudes of two short arcs, one at or very near the extremity of each axis, two extreme values of the radius of curvature can be computed, and from these, theoretically, the complete form and dimensions of the ellipse can be determined. Thus the problem of determining the form and dimensions of the earth could be solved by measuring the lengths and angular amplitudes of two short meridian arcs, one near the equator, the other near the north or south pole.

The angular amplitude of an arc of the meridian is obtained by measuring the latitudes of the extremities of the arc, that is, the angular altitude of the celestial pole above the horizon at these two points. The difference between these latitudes is equal to the angular amplitude of the arc. The length of the arc, evidently, cannot be measured directly. It is determined by a process known as triangulation, which is illustrated by Fig. 2.

Let A and F be the two points whose latitudes have been determined. In practice, these points are situated near, but not precisely on, the same meridian, XY. Several auxiliary points, B, C, D, E, are established and the points A and F are thus connected by a series of triangles. All of the angles of these tri-

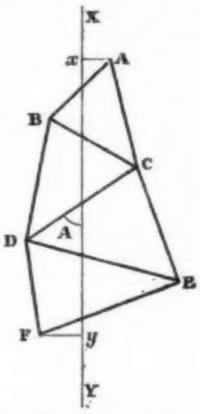


Fig. 2.—MERIDIAN TRIANGULATION.

angles are measured, as well as the angle of azimuth which one of the sides, AB, for example, forms with the meridian. The length of one of the sides, AB, for example, is then measured directly with the greatest possible precision, to serve as a base line. From these data it is possible to calculate the lengths of all the sides of the triangles and the lengths of the projections of AB, BD, and DF upon the meridian. The sum of these projections is the length of the meridian arc xy. As x is the projection of A and has the same latitude as that point, and similar relations exist between y and F, the angular amplitude of the arc xy is equal to the difference between the latitudes of A and F.

When the earth is said to have the form of an ellipsoid of revolution, the inequalities of its surface are neglected. The problem of geodesy is the determination of the form and dimensions of a theoretical solid, called the geoid, having the surface of a waveless and tideless ocean covering the entire globe. The geodetic points which form the apices of the triangles considered above are situated at various heights above the surface of the geoid. Great mountain ranges near these points introduce errors into the measurement, both of the length and of the angular amplitude of the arc.

Let us suppose that the extreme points of the arc, S_1 and S_2 (Fig. 3) are elevated above the geoid surface on mountains (not represented in the figure). The distance between them is evidently different from the distance between the points s_1 and s_2, directly beneath them on the geoid surface. Hence it is necessary to know the altitude of each of these points with greater precision than can be obtained with the barometer. Every geodetic survey, therefore, includes an operation in leveling by which the elevation of one

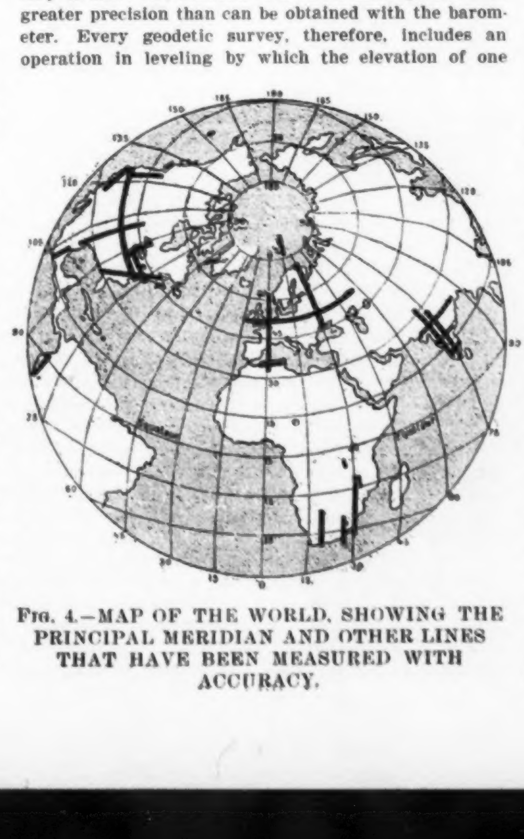


Fig. 4.—MAP OF THE WORLD, SHOWING THE PRINCIPAL MERIDIAN AND OTHER LINES THAT HAVE BEEN MEASURED WITH ACCURACY.

point above sea level is measured with the greatest possible accuracy. The altitudes of the other points are then obtained by means of zenith distances. If, for example, the altitude of the point A (Fig. 2) is known, the angles which the lines AB and AC make with the vertical are measured. As the lengths of these lines have been calculated the heights of B and C, above or below A, can be computed. The process is repeated, from point to point, until the height of F is determined.

The second error introduced by mountain masses affects the angular amplitude of the arc. Consider the points s_1 and s_2, at the bases of the mountains M_1 and M_2 (Fig. 3). At these points the plumb line is deflected from the vertical by the attraction of the mountains, so that the lines thus determined form with each other an angle greater than the angle included between the true normals to the surface (represented by the dotted lines). The error would be in the opposite direction if the points s_1 and s_2 were situated between the two mountains. The error is eliminated by methods which are too complicated to be described here.

These are not all the difficulties which are encountered in geodesy. Nature very rarely assumes the simple forms which we ascribe to it. Even if we agree to neglect the inequalities caused by mountains and continents, the section of the earth's surface by a plane passing through the poles would not be an ellipse or any other regular curve. Hence, instead of two arcs, many arcs must be measured in order to detect the local peculiarities of the curve, which can be com-

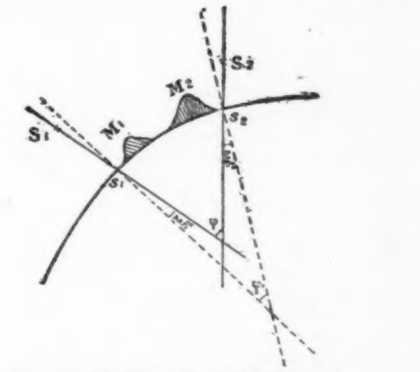


Fig. 3.—EFFECT OF MOUNTAINS.

pletely determined only by a triangulation extending from pole to pole.

The problem is still further complicated by the fact that the earth is not strictly a solid of revolution. Its sections by different meridian planes are not quite alike, so that the results of the measurement of one entire meridian could not be applied, without error, to other meridians.

These considerations have led scientists to multiply measurements of arcs in various parts of the world, and to measure, in addition to meridian arcs, arcs of the small circles of latitude which bound sections perpendicular to the axis.

Many geodetic surveys have been undertaken by the great nations of the world during the past two hundred years. The desire to co-ordinate and unify future surveys, led, in the latter part of the nineteenth century, to the formation of the International Geodetic Association, composed of delegates from all the countries interested, which has organized several recent expeditions for the purpose of filling important gaps in our knowledge of the form of the earth. A few years ago these gaps were numerous. Although the greater part of Europe was covered with a fine triangulation, few accurate surveys had been made in less accessible regions, especially near the equator and the poles.

The necessity of knowing the lengths of meridian arcs in extreme latitudes became evident early in the eighteenth century. In 1735 the French Academy of Sciences took the initiative by sending expeditions to Lapland and Peru for the purpose of measuring meridian arcs. Four academicians, Maupertuis, Claraut, Camus, and Lemonnier *fils*, were attached to the polar expedition, which returned with its task accomplished in sixteen months. The equatorial expedition was very much longer, owing to the numerous difficulties which confronted it and also to disagreement among its leaders, the academicians Godin, Bouguer, and La Condamine, who were led by mutual discord and a spirit of

adventure to return by very different routes. Bouguer arrived in France in 1743, after having traversed Colombia from south to north; La Condamine in 1745, after having navigated the Amazon from Peru to Para in Brazil; and Godin in 1751, after having crossed the continent from Lima to Buenos Aires.

Although the recital of the petty quarrels of these eminent men makes the story of their perilous wanderings unpleasant, it is impossible not to admire the splendid courage, zeal, and fidelity to the cause of science which they displayed throughout.

The measurements made by these two expeditions have furnished the basis of all subsequent calculations and theories of the form of the earth. But the excellence of the observers could not compensate for the imperfection of their instruments and methods, and modern geodesy could no longer be satisfied with the degree of precision which appeared sufficient to the scientists of the eighteenth century.

It was necessary to obtain new measurements of polar and equatorial arcs which would be comparable with measurements made in mean latitudes with modern instruments and methods. Russia and Sweden undertook the measurement of the polar arc and conjointly sent to Spitzbergen an expedition which, between 1898 and 1902, measured the length of an arc of 4 deg. 10 min. about 625 miles distant from the North Pole.

France insisted on her historical right to measure the equatorial arc and her claim was allowed by the other nations. In 1901 five French officers and twenty soldiers started for Ecuador. In 1906 the expedition returned, after having measured an arc of 5 deg. 54 min.

The republic of Ecuador is crossed from north to south by two mountain ranges, which have a mean height of 13,000 feet, and include many snow-clad peaks and volcanoes, some of which are nearly 20,000 feet high. These parallel cordilleras inclose between them a rolling plateau, 20 to 25 miles wide and from 8,000 to 10,000 feet above sea level, which enjoys a mild and uniform climate and is the most productive and most densely populated part of the country. On both sides of the cordilleras extend hot and moist regions covered with virgin forests and little touched by civilization. Narrow strips of cultivated land extend along the Pacific and the rivers. The only large city is Guayaquil, the chief port of Ecuador.

Although the presence of these two parallel ridges, stretching nearly north and south, greatly facilitated the execution of a meridian triangulation, it compelled the use of geodetic points situated on cliffs from 11,000 to 15,000 feet high, often remote from inhabited regions, so that the observers were isolated on the barren, denuded, damp, and cold "paramos," or lofty plateaus that crown the peaks of the cordilleras. Immense difficulties attended the transportation of heavy and delicate instruments to elevations of 13,000 feet by barely discernible mule paths, which were often made impassable by tropical rainstorms.

The operations were further delayed by the fogs and clouds which often shrouded the mountain peaks for weeks. The work at some of the stations, which could have been completed in a week of fine weather, occupied several months. Another obstacle was presented by the superstition of the Indian natives, who destroyed many of the wooden monuments erected at the stations.

Despite all these difficulties the work was successfully accomplished. The calculation of the arc of Quito is now in progress and will be completed in about four years.

The importance of the measurement of this arc will be made evident by a glance at Fig. 4, which shows a map of the earth on which are indicated the principal arcs which have been measured with precision. One meridian has been measured through 27 deg. 2 min. of latitude from the Shetland Islands, through England, France, and Algeria, to the Sahara; another meridian through 25 deg. 20 min. from the Arctic Ocean to the Danube. The British have covered India with a fine network of triangles and have carried through 21 deg. 36 min. from the Cape of Good Hope to Lake Tanganyika, a meridian triangulation, which will be gradually extended through Egypt to Cairo.

The work that has been accomplished or is in progress in the United States is still more extensive, but we can mention here only the survey of the 98th meridian, which will extend 23 deg. from the Mexican to the Canadian frontier, and will be connected with the arc measured by the Mexican geodetic commission. The arcs of Spitzbergen and Quito form very valuable additions to this mass of observations and furnish data exceedingly important for the exact calculation of the form and dimensions of the earth.

Geodesy is not merely a science of speculative interest, but has numerous practical applications. The map of a country cannot be drawn correctly without determining a number of points of reference with very great precision by geodetic triangulation.—Translated for Scientific American Supplement from La Science au XXme Siècle.

THE YEAST CELL AND ITS LESSONS.*

THE PHENOMENA OF FERMENTATION.

BY W. STANLEY SMITH.

It has often struck me that the debt modern science owes to that simple organism we call the yeast cell has, perhaps, never been sufficiently considered by the majority of well-educated mankind. It may be that in the haste and turmoil of industrial life many details of considerable fascination must necessarily escape our ken; it may be, alas! that some of us are content to live our lives among phenomena of which, as Sir Oliver Lodge once said, "we care nothing and know less." Be this as it may, I venture to think that an odd half-hour spent in those delightful fields of thought which envelop yeast and its simple cellular life will not prove entirely unpleasurable, nor, indeed, without some measure of intellectual profit.

I do not propose to delve far back into the dusty records of time. It will suffice for our purpose if we place ourselves beside the old Dutchman, Van Leeuwenhoeck, and take a glance through the early microscope of 1680. In the field of vision many globules floating in a fluid will be discerned; and these, forsooth, are yeast cells seen in their naked simplicity for the first time by mortal eye. It was thus found that brewers' barm possessed a definite structure, and the primitive step in a long series of discoveries duly accomplished; but it is curious to reflect that 150 years should then intervene during which nothing of capital importance was added to our knowledge. With the advent of the nineteenth century, however, each day brought forth its measure of scientific progress. The scene, indeed, became crowded; men flocked hither and thither declaring novel facts and fancies, and a veritable whirlpool of conflicting statement and contending argument ensued. At this distance of time the multitude grows dim; but certain figures stand out, and are conspicuous among their clamorous fellows. We must note at least four remarkable personages—by name, Schwann, de Latour, Berzelius, and Liebig. The labors of de Latour in France and Schwann in Germany were almost simultaneously crowned with eventful discovery. Yeast, they announced with no uncertain voice, is a living, breeding, entity, and, moreover, is the cause of the fermentation of sugar. All this happened during the opening year of the Victorian age, and against these strange utterances many a voice was raised. Those of us who have studied the history and progress in the fermentive arts will easily recall some of the wild and fantastic guesses which were then poured forth; but among much intellectual dross there rang out the reasoned opinions of Berzelius, the Swede, and Liebig, the giant of his time. Berzelius had, without doubt, as early as 1827, and with greater certainty in 1839, regarded fermentation as dependent upon catalytic force, or, as he called it, *vis occulta*, and Liebig, whose chemico-mechanical theory held ground for some years, is best interpreted by quoting his own words, as they appear in the classic "Chemistry of Agriculture and Physiology." "In the metamorphosis of sugar," says he, "the elements of the yeast, by contact with which its fermentation was effected, take no appreciable part in the transformation of the elements of the sugar; for in the products resulting from the action we find no component part of this substance."

Many other theories echo from out those times—theories, for the most part, utterly vanished from the ken of practical science. Albeit a strange value, a vague sense of prophecy is discernible in certain of these long-forgotten figments of scientific imagination. For instance, one might legitimately recall Mitscherlich, with his notion of contact, much akin to the action of platinum sponge, or Meissner, with his purely chemical theory, or, yet again, the strange forecast of Colin and Kaemtz, who deem the whole matter wrapped deep in the mysteries of electricity. Suffice it we have chosen enough for our wants, and it will be apparent how, in the whirligig of time, forgotten lore will suffer resurrection. In the history of science instances are, indeed, not wanting in which old theory clothed in the garb of newly-found facts itself lives anew.

The learned Gabriel Schwann was, by inclination, a physiologist, and his work on yeast must be regarded in the light of experimental means to an ambitious end. He sought in the cell the very foundation of life. "I have been unable," says he, "to avoid mentioning fermentation, because it is the most fully and exactly known operation of cells, and represents in the simplest fashion the process which is repeated by every cell of the living body." Let us place these words side by side with those uttered but the other day by the great Verworm. "It is the cell to which the consideration of every bodily function, sooner or later, drives us. In the muscle-cell lies the riddle of the heart beat, or of muscular contraction; in the epithelial-cell, in the white blood cell, lies the problem of the absorption of food; in the gland-cell are the causes of secretion, and the secrets of the mind are slumbering in the ganglion-cell." It thus appears clear that the simple saccharomycete is typical, even as Schwann argued, of all organized life. But it is not a mere question of crude morphology; this, indeed, is but the least subtle of those analogies which the study of a yeast cell will suggest. As we gaze through the eyepiece of some sufficient microscope or better still observe the seething world of the brewers' fermenting vat, we may be tempted to ask the old, old question, Whence and Whither? What lies behind this fierce energy of decomposition, this astounding fecundity, this altogether absorbing mystery of life? These are the problems which men of science have set themselves to solve, and already they have gone far. I think that it would not be difficult to refer the latest opinions of biologists to the direct and logical result of reasoning which was primarily suggested by research on the mechanism of the yeast cell. "Physiology's present answer to the old question," says a recent writer, "is, very simply, life is a series of fermentations." And, if it be urged that we do not yet know what is fermentation, that we know as little of the working of the housewife's barm, or the brewer's malt, as of the life itself, there will be no one to gainsay. For, curiously enough, they seem one and the same thing.

There is a plate let in above the doorway of a house at Dôle, in the Rue des Tanneurs, on which is inscribed this simple phrase: "Ici est né Louis Pasteur, le 27 Decembre, 1822." And, while I may unhesitatingly say that few more momentous events have occurred in the annals of science, I am tempted to add that Pasteur's birth was of equal moment to the whole of humanity. For what manner of man was this lowly-born tanner's son? And what was the outcome of his labors? Let Lord Lister tell us in his own grateful words. He said: "Pasteur's researches on fermentation have thrown a powerful beam which has lightened the baleful darkness of surgery, and has transformed the treatment of wounds from a matter of uncertain, and too often disastrous, empiricism into a scientific art of sure beneficence." Pasteur's life has been laid bare to us by several writers, among them his son-in-law Bompas, and, in a clever little monograph, by Mrs. Percy Frankland. From the latter work we gather how Pasteur, in his youth, was much addicted to the gentle Waltonian art. Indeed, for some years he took no heed whatever of books or other dry-as-dust learning. It was not until dire necessity forced him that fishing-rod, paint-box, and other profitless joys were forsaken, and our student at the Sorbonne discovered his God-given gifts. And then a certain old woman of Arbois, in her rural wisdom, made this odd remark: "What a pity," said she, "that Louis should bury himself in a muck-heap of chemistry, for in truth he would some day have succeeded in making name and fame as a painter."

It is a legitimate question to ask why Pasteur happened to take up the study of fermentation. The answer affords another of those happy chances which are the salt of scientific life. As a crystallographer he was bent on solving those old problems suggested by the tartaric acids. He noticed how one type of this acid deflects the beam of light to the right, another to the left. Further, he chanced to observe that certain micro-organisms exercise a selective action when sown in these solutions—thriving in one, pining in the other. Here then was a clue, for surely the

* Knowledge and Scientific News.

contents of the cells Schwann had declared alive must control such dainty selective action. What followed in those fruitful years it were quite needless for me to recapitulate. Liebig and his molecular oscillations were forgotten by all save the faithful few, and for forty years mankind reveled in the thought that the fermentation of sugar was indissolubly connected with the life action of a living organized structure. Yet, on the crucial point, Pasteur was in error. It must not be forgotten, however, that by his classical experiments with the isomeric tartaric acids Pasteur practically laid the foundations of stereo-chemistry. The development of this fruitful branch of learning was, necessarily, slow at first, and indeed, it was not until 1873 that much headway was achieved. In that year Wislicenus pointed out the deductions of his work on lactic acid, and it seemed clear to men of science that the difference between compounds of identical structure was due to differences in the "arrangement in space" of atoms within the molecule. It is to the further development of this difficult subject, at the hands of Le Bel and van't Hoff, who elaborated the theory of the asymmetric carbon atom, that we largely owe our knowledge of the carbohydrates.

The new century opened with new ideas. A book dealing with experimental research on alcoholic fermentation, and relating the results of laboratory experiments dating from 1896, appeared in the year 1903. It is entitled "*Die Zymasegärung: Untersuchungen über den Inhalt der Hefezellen und die biologische Siete des Gärungsproblems*." The authors' names are Eduard Buchner, Hans Buchner, and Martin Hahn; and it became evident something noteworthy had happened. It was briefly this: Buchner, unhampered by any prejudice concerning the connection of vitality with fermentation, betook him to see what was really inside the yeast cell. Accordingly, he mixed a small quantity of barm with very fine sand, and he then subjected the whole to enormous pressure. This hard quartz crushed the little yeast cells to merest pulp, and therefrom flowed a wonder-working fluid. It was found that Buchner's liquor effected exactly the same fermentation in a saccharine solution as did yeast itself. This research of Buchner's actually proved what was long ago conjectured by Liebig, Traube, Berthelot, and Hoppe-Seyler, namely, that the intra-molecular transformation of sugar into alcohol and carbon dioxide is due to an enzyme secreted within the yeast cell.

This capital demonstration forms a fitting climax to a long series of speculations on collateral fermentations. We will call to mind the main results achieved by toilers in these different fields of research. In the year 1841 two French chemists, Payen and Persoz, succeeded in isolating from germinating barley a substance which seemed to possess an unlimited capacity for saccharifying starch. They called this substance *diastase*. Later on, in 1860, we find Berthelot experimenting with yeast, and he isolated the substance to which Béchamp, in 1864, gave the name *zymase*. Thirty years after Donath changed this name to *invertin*, and we thus clearly have species of chemical substances which, when abstracted from living organisms, are able to effect certain well-defined fermentations. Meanwhile, it has been shown that many processes of higher life appear to be governed by these soluble, unorganized ferments, or, as Kuhne, in 1878, proposed to call them, *enzymes*. Incidentally, I should here mention that, like many other *termini technici* with which we are familiar, these expressions, ferment, diastase, enzyme, or what-not, must be understood historically; just as logic, metaphysic, analytic organon, etc., can only be apprehended and understood historically. In 1831 Leuchs discovered that saliva possessed the property of saccharifying starch, and fourteen years after Mialhe isolated the ferment, and called it *salivary diastase*, a name far preferable to that bestowed upon it by Berzelius, but which remains to this day, I mean *ptyalin*. Then followed the discovery that the specific functions of the stomach, liver, and pancreas were each controlled by their specific ferments, which we shall recognize as *pepsin*, *rennet*, and *ptyalin*. And now, as the result of the brilliant young Gabriel Bertrand's work, we are even bid to associate the taking up of oxygen by the lungs with the necessary presence of an enzyme, which he has called, appropriately enough, *oxydase*.

It is now possible to discern the connection of Buchner's bold experiment with all this more purely physiological work. He proved that the phenomena apparent when yeast is added to the brewers' wort are identical in principle with all these other fermentive actions, and all the research of more recent years tends but to strengthen one's opinion that the most important functions in the economy of life are under the control of enzymes, or, in other words, partake of the nature of fermentation. Quite recently Dr. Harden has had something to say about zymase. His memoir is illuminating, and, if that were possible, still further opens our eyes to the complexity of the subject. He indicates the presence in yeast juice of "something" of an organic nature which is not affected at boiling temperatures, and to which it owes its power of converting sugar into alcohol and carbon dioxide. Should this nameless "something" be withdrawn from yeast juice, zymase almost loses its characteristic; but, on the other hand, if more be added, so as to swell the normal quantity, the action of zymase may be doubled or quadrupled in ratio to the quantity present. We touch here upon the difficult problems connected with the so-called co-ferments, and we are clearly on the fringe of important discoveries. Indeed, many facts are already at hand which only want of space compels us to withhold for the purposes of the present article. Some German chemists, Bredig among others, have been able to imitate very closely certain fermentations by means of finely-divided metals, such as platinum or gold, and these curious ferment-like solutions may be "poisoned," chloroformed, or killed just as if they were alive. This is all extremely odd, and most perversely mechanical; but there is something behind these phenomena which awaits correlation with vinous fermentation. Meanwhile, about three years ago the Zeitschrift für Physikalische Chemie published the following remarkable research, which must furnish us with all the evidence we have leisure to adduce on this occasion: In the course of his paper on the "Influence of Metals on the Hydrolysis of Cane Sugar," R. Vondrácek draws attention to the fact that authorities differ "as to the effect of metals on the well-known slow inversion of saccharose by boiling water," and proves experimentally that strips of platinum foil do not appreciably influence the rate of inversion, thus confirming the results obtained by Lindet. On the other hand saccharose (cane-sugar) is rapidly inverted by boiling water in the presence of platinum black. Sugar solutions acquire a decidedly acid reaction by heating with platinum black for 15 minutes, and the filtrates undergo inversion on further heating. If after inverting a sugar solution by treatment with platinum black for eight hours the powder be immediately heated with a fresh solution, the latter develops no acidity, and it is not inverted more rapidly than by water alone, but the inverting property of the platinum black is restored by exposure to air. Again, platinum black which has been previously deoxidized by treatment with ammonia, has no influence on the rate of inversion by pure water. From these data it is concluded that the inversion by platinum black is due to the oxygen contained in it, which oxidizes a part of the saccharose to one or several organic acids, and thus supplies hydrogen ions to the solution.

But fermentation is destructive. The ferment of yeast splits up sugar into alcohol and carbon dioxide; pepsin resolves albuminous foodstuffs into substances of, presumably, simple molecular composition, and so all through the list we have had occasion to mention. On the other hand, side by side with this incessant destruction, life is characterized by incessant construction. These form, indeed, the two most striking and essential phenomena of the life process; the destruction, the analysis, is death; the construction, the synthesis, is life. And a constructive ferment appears, from our knowledge of enzymes, to be a plain contradiction in terms. However, even this stumbling block has apparently been removed, and it was a young Englishman, Croft-Hill, who first showed us that a constructive ferment is not only thinkable, but that it actually exists. And here again the lesson was furnished by a yeast cell. In the month of June, 1899, a paper was presented by Croft-Hill to the Chemical Society, in which it was shown that the action of the maltase of yeast (which is the enzyme charged with the special function of converting the sugar maltose into the simpler, and more readily fermentable, sugar glucose) on maltose is hindered by the presence of glucose, and is incomplete. The effects are more marked the stronger the solution of maltose. If the maltase be allowed to act on a 40 per cent solution of glucose, there is an apparently reversed hydrolytic action resulting in the formation of 15 per cent of maltose, at which point equilibrium occurs. The same equilibrium point is reached whether we start with a solution of maltose or glucose, so that the action is clearly a reversible one. It has often struck me that the divergent results various chemists have achieved in the study of the decomposition of starch may, perhaps, in some measure be accounted for by the action of constructive enzymes, or rather, one would be safer in saying, by the general tendency, under defined conditions, for reversionary processes to become manifest. It is rather more than twenty years ago since Dr. Wohl noted the phenomena of inversion and reversion in connection with the action of weak acids on certain complicated sugars.

If further evidence be required as to the possibility of what I have named constructive ferments, it may be found in Emmerling's work, which I mention with reserve, on amygdaline. Under the influence of one enzyme, emulsin, this substance is split up into sugar, hydrocyanic acid, and the essence of bitter almonds. But it is said that another ferment, maltase, common to yeast, will join these decomposition products together again to form the original substance.

On one very particular point, that is to say, the molecular construction of these enzymes, ferments, or diastases, the world of science is almost entirely ignorant. This question forms one of the many chemical problems of the hour, and we start with the shallow fact that they contain the simple elements found in charcoal, air, and water. Beyond this we know next to nothing. I think, however, we may console ourselves with the reflection that we are at least on the eve of important discoveries. My friend, and former "chief," Emil Fischer, of Berlin, having vied with Nature herself in the manufacture of sugars, has now turned his attention to proteid substances. The intervening gulf has already been bridged, inasmuch as Fischer has traced the connection between the configuration of a sugar and its behavior toward ferments. This is the famous "Schloss und Schlussel" theory, the happy analogy of "lock and key." It is our every-day experience that yeast cells assimilate more easily the sugars of which the molecular configuration closely resembles that of the most digestible of all carbo-hydrates, namely, glucose. Many of the artificially produced sugars, as for example the aldoses, gulose and talose, are quite indifferent to the fermentive efforts of yeast, and the complicated bi- and tri-saccharoses are, for the most part, resolved into simpler molecular constructions before suffering the usual decomposition.

There is a fertile field of inquiry open to investigation as to whether some of the curious by-blows of fermentive action may not lead to further discrimination between constructive and destructive fermentation. We have certainly arrived at a point, in so far as these studies are concerned, which bids us be cheery as to the future, for the modern man of science has far outstripped those learned forbears of his who, to use Sir Edward Elgar's lugubrious simile, were like "blind men in a churchyard at midnight, trying to read epitaphs in a forgotten tongue." Emil Fischer's work alone has inspired that able chemist, Dr. M. O. Forster, in saying, "It is permissible to prophesy that his contemporary researches among purine derivatives and synthetical polypeptides will culminate in dramatic results, as they have the character of a reconnaissance preceding an attack on the proteids, which chemists anticipate will share the fate of the two other principal food materials—fats and sugars." Dr. Gustave Mann, of Oxford, in his erudite work on the Chemistry of the Albuminoids (a work based on Cohnheim's treatise, but which forms a much expanded version of the original) strikes the student on its perusal as predicting the early synthesis of an enzyme. Indeed, the advances chronicled therein are potential to a singular degree; but it is not yet time for the full fruits of those hundred-fold labors, directed primarily to the elucidation of yeast and fermentation, to fall to the husbandman's sickle.

It has only been possible for me to touch upon one or two of the manifold thoughts which suggest themselves when one watches the activity of yeast. I might have mentioned the interest which was aroused by the publication of Dr. de Backer's volume, "Les Ferments Thérapeutiques," in 1896; wherein it is noted in how curious a manner the yeast cell will swallow up certain bacteria, pathogenic and otherwise, and it is shown how subcutaneous injections of yeasts may possibly be used to destroy the germs of many dire diseases. Again, in proof of the medicinal effects these microscopical cells will occasion, I might have quoted the, perhaps hypothetical, story of the Hertfordshire farmer, who went home late one night and drank a pint of yeast in mistake for buttermilk. He arose three hours earlier next morning. Indeed, the thoughts which crowd around these simple cells partake of a character almost universal. To yeast we owe the nation's bread, and the nation's second necessity, beer; and many other needful liquors are ours through the medium of yeast. So wide is the survey that the disjointed reflections I have ventured to place before you form but a tithe of those our theme might legitimately evoke. But all these must now be passed over, and we will conclude with one modest Faust dream. If Croft-Hill is right, and the action of maltase is reversible; if Emmerling's discovery that one ferment may undo the work of another be a true interpretation of Nature, then might we not expect the same reasoning to apply, under conditions yet unknown, to those ferments which convert living protoplasm into relatively dead fatty, connective cartilage or bone tissue? Metchnikoff has declared this process is the invariable symptom of advancing years, and we may quite legitimately ask in what manner this apparent discovery of constructive ferments will ultimately affect such momentous problems.

Greasing Medium ("Mucyline").—5 parts of glycerine at 28 deg. B., mixed with 9 parts of potash soap, added to 10 parts of water in which 0.010 part of sulphate of zinc has been dissolved.

OXHYDRIC PROCESS OF CUTTING METALS.—I.*

TORCHES AND MACHINES THAT CUT STEEL.

BY E. F. LAKE.

It is seldom that the American Machinist has the privilege of publishing such a striking addition to machine-shop methods as the one which supplies the subject of this article. When we say that Fig. 1 represents a piece of 9-inch chrome-nickel steel armor plate which has been cut to a circular outline by the removal of the waste piece shown in the left foreground, and that this has been done at the rate of a linear foot of cut in 2¼ minutes, we think we are saying enough to indicate that here is something new in the machine shop.

Figs. 2 and 3 are added, the former to show the arrangement of the apparatus preparatory to the cut and the latter to show the work in progress with the pyrotechnic display that accompanies it. Further on in this article additional examples of the work done will be shown which are less striking than the one which forms the subject of the first three pictures only because of the smaller sizes of material acted upon. In some respects—notably the form of the cut made in some of the examples—these latter cases are, indeed, more striking than the ones shown in Figs. 1, 2, and 3.

The remarkable results are obtained by an apparatus which is a development from one patented in 1901 by the Cologne-Meusen Mining Company for opening plugged blast-furnace tap holes and now in considerable use in this country, where it has cut tap holes through 4 feet or more of solid metal, and with a reduction of time from days to as many hours. That apparatus, like this, makes use of two nozzles through one of which a mixture of oxygen and hydrogen is supplied, while the other delivers pure oxygen only. The action of the older apparatus is, however, to actually melt the metal, and while very effective for its purpose, it is by it impossible to produce a smooth and exact cut of any desired length.

With the present apparatus a preheating nozzle, shown at the right of Fig. 6 (see next installment), delivering mixed oxygen and hydrogen, is used to continuously heat the metal, while immediately following it, and set at an angle such that both streams of gas strike the metal at the same place, is a second nozzle delivering pure oxygen only. This cuts the metal by oxidizing it without melting and blows away the oxides by the force of the blast. The result is a cut which may be fairly compared with that made by a cutting tool, as shown in Fig. 5, while the heating is so local that the properties of the material cut are not affected beyond about 1/64 inch of the cut surface and the width of the kerf is surprisingly small.

The oxhydric process is based on the well-known fact that iron burns easily and rapidly in an atmosphere of oxygen gas, as much heat is thus set free. If we throw a jet of oxygen upon iron that has been heated to a red, the oxygen oxidizes the metal, which

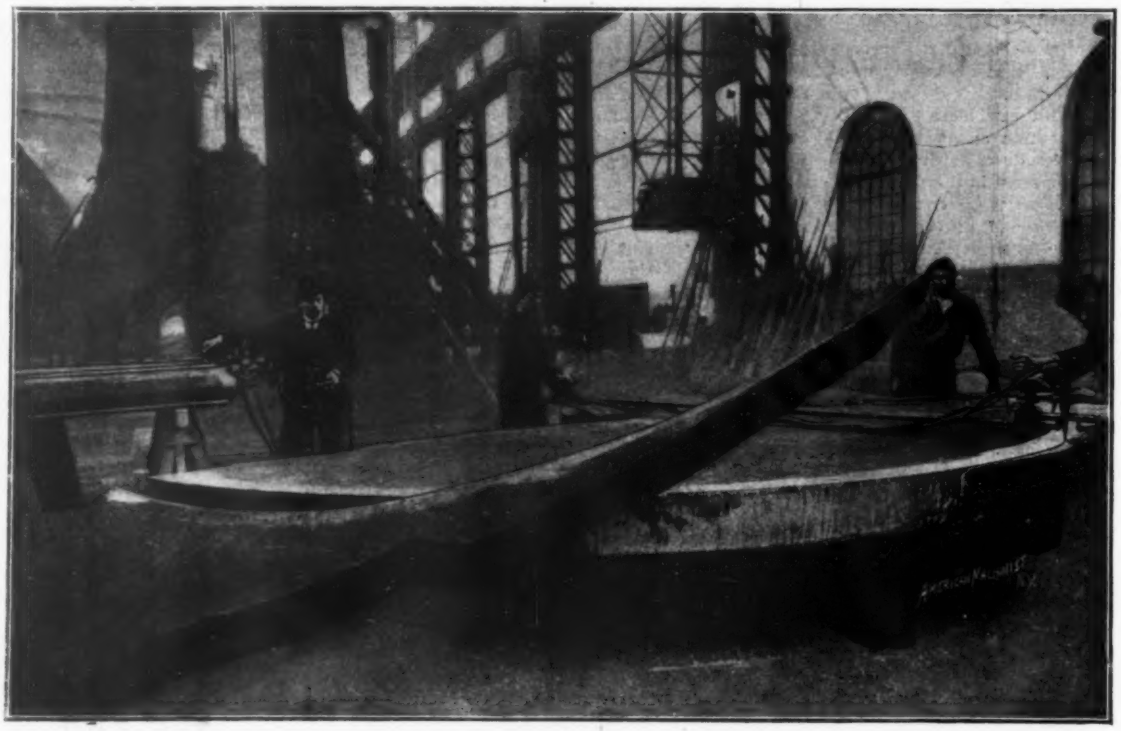


FIG. 1.—A 9-INCH NICKEL CHROME-STEEL ARMOR PLATE AFTER ONE-HALF THE CIRCLE HAS BEEN CUT AT THE COCKERILL WORKS, SERAING, BELGIUM.

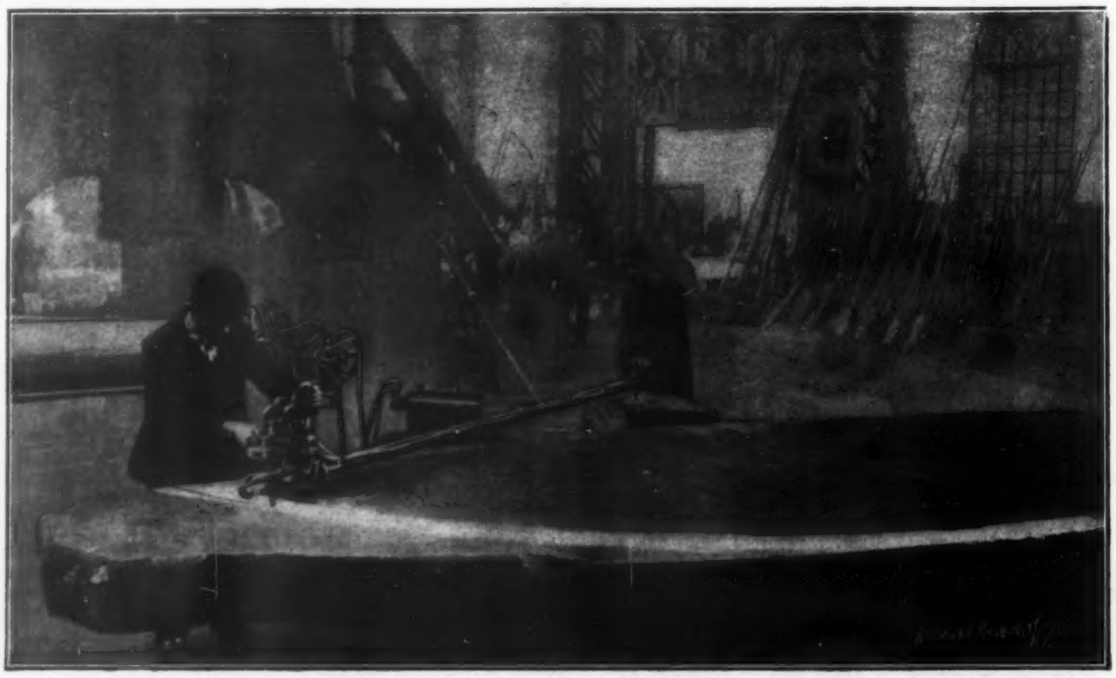


FIG. 2.—GETTING READY TO MAKE THE CUT WITH TRAMMEL POINT AND BEAM MACHINE.

THE OXHYDRIC PROCESS OF CUTTING METALS.

* By courtesy of American Machinist.

is to say, burns it. Thus the steel is heated only to from 1,300 to 1,500 deg. F., as at this temperature iron has a great affinity for oxygen, and the combination produces different forms of oxides.

The double-nozzle torch may be manipulated by hand, or it may be guided by any sort of mechanical arrangement; and thin sheets or thick plates, steel tubes, structural shapes, castings, or any odd pieces of steel may be easily cut.

The cut can be made to follow any sort of a line whatever, as all forms of curves and odd shapes are cut as easily as the straight line. The cut is not necessarily square to the surface, as a beveling cut can be easily made, and it is practically no wider at the bottom than at the top even when cutting very thick metal. The speed of travel of the torch can be made about 8 inches per minute on fairly thick metal, and this makes it compare very favorably with hot sawing.

The composition of the steel or its mechanical treatment does not affect the speed with which the metal is cut, or the amount of gas which is used in the cutting. In fact, there is no variation between the rolled, forged, or cast steels and the soft, hardened, tempered, carbonized or Harveyized steel, and a nickel chrome, high-manganese or high-carbon steel cuts as easily as the low-carbon steels.

The complete apparatus for cutting, with one of the mechanical appliances for guiding the torch, is shown in Fig. 4. The two steel bottles at the right of the picture contain the oxygen and hydrogen which is stored under a pressure of from 1,500 to 2,000 pounds per square inch.

Each bottle is provided with a needle valve to which is attached a pressure regulator governing the flow, so that the gas will be delivered to the mixer and

FIG. 3.—CUTTING THE 9-INCH NICKEL CHROME PLATE AT RATE OF 2¼ MINUTES PER LINEAL FOOT.

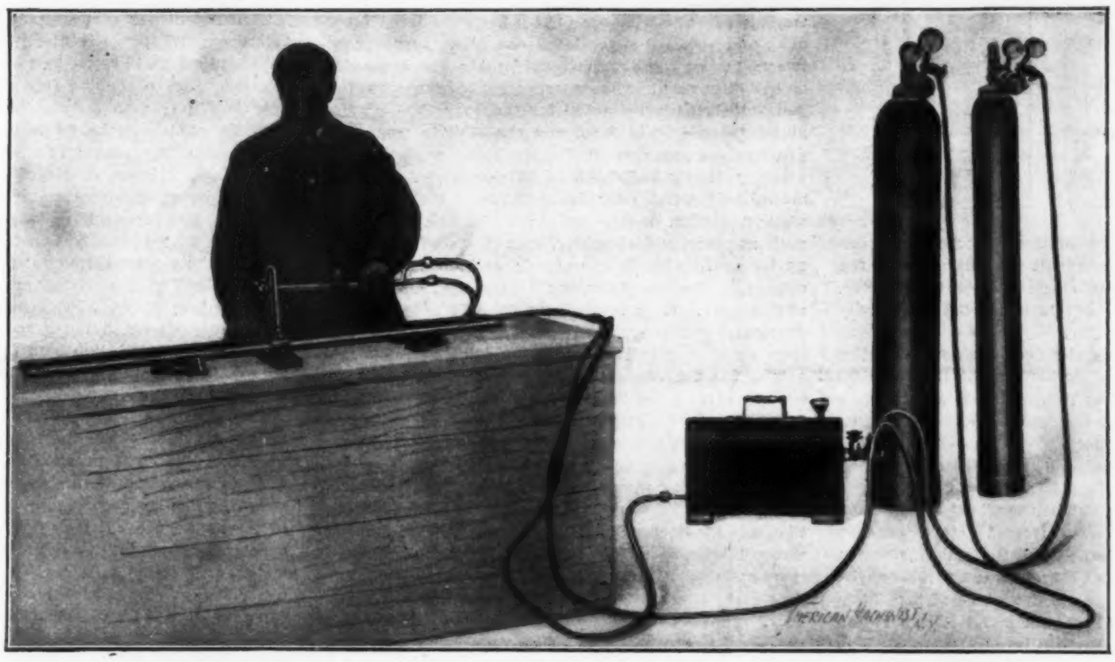


FIG. 4.—OXHYDRIC APPARATUS WITH MECHANICAL APPLIANCE FOR CUTTING IN A STRAIGHT LINE.

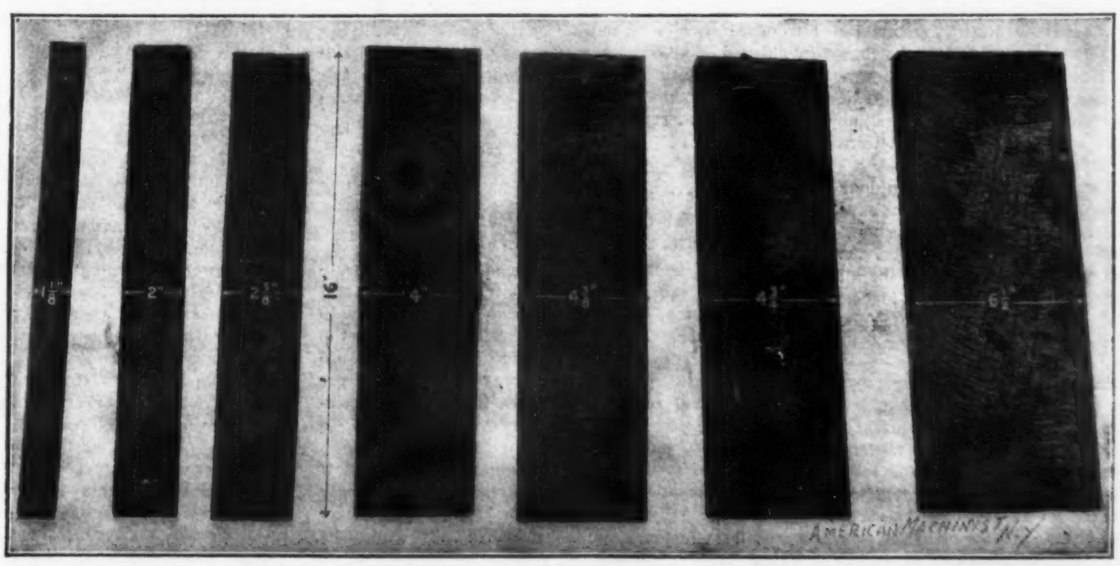


FIG. 5.—CUT SURFACE OF STEEL SLABS, FROM 1⅛ TO 6⅛ INCHES THICK, CUT WITH MACHINE IN FIG. 4.

THE OXHYDRIC PROCESS OF CUTTING METALS.

from thence to the torch at a constant pressure. A high-pressure gage is located between the needle valve and pressure regulator in order to show at all times the contents of the tank and to determine the amount of gas consumed in any cutting operation. A low-pressure gage is also attached to the regulator showing the

TABLE I. GASES USED IN CUTTING SLABS SHOWN IN FIG. 5.

Number of Piece Counting from the Left.	Thickness of Metal in Inches	Consumption of Gas for Each Lineal Foot of Metal Cut.	
		Oxygen.	Hydrogen.
1	1⅛	3.9	3.9
2	2	4.8	4.8
3	2⅝	8.3	5.8
4	4	14.4	7.7
5	4⅜	15.5	8.8
6	4¾	17.5	9.0
7	6½	22.3	10.3

TABLE II. AMOUNT OF GAS AND SIZE OF TORCH USED WHILE CUTTING STEEL FROM 1/10 TO 5 INCHES THICK.

Thickness of Metal, Inches.	Size of Nozzle for Cutting or Oxygen Torch, Inches	Size of Nozzle for Heating or Oxhydric Torch, Inches	Cubic Feet of Gas Used for Each Lineal Foot of Metal Cut.	
			Oxygen.	Hydrogen.
0.2	0.06	0.12	1.5	1.5
0.4	0.06	0.12	1.9	1.9
0.6	0.06	0.12	2.2	2.2
0.8	0.06	0.12	2.5	2.5
1.0	0.08	0.16	2.9	2.8
1.2	0.08	0.16	3.3	3.2
1.4	0.08	0.16	3.8	3.4
1.6	0.08	0.16	4.4	3.6
1.8	0.08	0.16	5.1	3.8
2.0	0.08	0.16	5.8	3.9
2.2	0.08	0.16	6.5	4.1
2.4	0.08	0.16	7.2	4.3
2.6	0.08	0.16	8.0	4.6
2.8	0.08	0.16	8.8	4.8
3.0	0.08	0.16	9.7	5.0
3.2	0.08	0.16	10.7	5.3
3.4	0.08	0.16	11.8	5.6
3.6	0.08	0.16	12.8	6.0
3.8	0.08	0.16	13.9	6.4
4.0	0.08	0.16	15.0	6.9
4.2	0.08	0.16	16.2	7.4
4.4	0.08	0.16	17.5	8.0
4.6	0.08	0.16	18.8	8.5
4.8	0.08	0.16	20.2	9.0
5.0	0.08	0.16	22.7	9.5

pressure of gas as used for cutting. The cutting pressure can thus be varied to suit the character of the work by turning a thumb screw on the regulator. From the regulator the gas is conducted by heavily armored tubing to the mixer.

The mixer is shown on the floor beside the bottles and the gases are conducted through it by a conical worm-shaped pipe made of thin metal, this pipe being surrounded by cool water as a safety provision against explosion of the mixed gases.

In Fig. 4 the torch rides on a frame that is provided with two ways for guiding it in a straight line.

In Fig. 5 is shown a number of slabs which have been cut from plates ranging from 1⅛ to 6½ inches in thickness. The cut surface of the slabs is shown and the lines showing the travel of the torch can be seen. On steel 4 inches thick, the width of the cut is only ⅛ of an inch, while on thin metal it is but 5/64 inch, and the metal is practically as smooth as that coming from a saw.

The principal item in the cost of cutting metal with this process is the gases used, as the apparatus is much simpler than that used for cutting metals by any other means, and requires no power, and the time of cutting is as quick if not quicker. The consumption of gas naturally depends upon the thickness of the piece to be cut. The amount of each gas used, as well as the thickness of metal of the pieces that were cut, as shown in Fig. 5, is given in Table I.

From the large amount of work which has been done and the numerous thicknesses of metal which have been cut, the amount of gases which should be used are pretty well known. In Table II is given the amount of the two gases which should be used for all thicknesses of metal from 1/10 of an inch to 5 inches, as well as the size of nozzle which should be used for each gas.

(To be continued.)

Salvage work on a steel steamer sunk in Shanghai Harbor, recently carried out by the caisson method, has been described in the Far Eastern Review. The steamer was loaded with pig iron and rails, and sank in about 25 feet of water on account of a collision which tore a hole in one side. As much of the cargo was removed by grab buckets as possible, and the rent in the side patched water-tight by divers. Two cofferdams of sheet steel, 78 feet by 18 feet by 21 feet high and 40 feet by 18 feet by 21 feet high, were erected—one over the main hatch amidships and one round the engine and boiler-room house, which was located aft, as in the Great Lake steamers. The caissons were well braced internally, and the water was then pumped out of the hold by three large pulsometers suspended over it and six 10-inch centrifugal pumps on pontoons moored alongside. It required only two hours of pumping to float the vessel, after which the caissons were removed and she was towed into the drydock of the Shanghai Dock and Engineering Company.

INTERNATIONAL STEAM FERRIES.*

The new direct steam-ferry connection between Sweden and Germany was recently inaugurated by the Emperor William and the King of Sweden. The new ferries will run between Trelleborg, in Sweden, and Sassnitz, in the Island of Rügen, between which two places there has, for some time, been regular daily steamer connection. The new steam-ferry traffic is thus competitive with the Danish-Mecklenburg Gedser-Warnemünde steam-ferry route. As with the latter, it is proposed to run two ferries daily in each direction, for which purpose four ferries are to be used—two for ordinary traffic and two as reserve; and the traffic catered for will comprise both mail and passengers, as well as goods. The Swedish and the Prussian State will work this route jointly, each country supplying two ferries. The trip lasts for about four hours at a speed of 16 knots. The cost of the two Swedish ferries was estimated at $1,250,000; in addition, the extension of Trelleborg harbor and the alteration of the railway station, etc., have entailed an outlay of $250,000.

The passenger traffic on the Trelleborg-Sassnitz steamer line has steadily increased, from 19,255 in the year 1897-8 to 38,243 in the year 1906-7. The goods traffic, on the other hand, has been comparatively unimportant, and has not shown a corresponding increase, which is considered due in part at least to the competition from the Gedser-Warnemünde steam ferry, Sweden having two direct steam-ferry communications with Denmark—viz., Malmö-Copenhagen and Helsingborg-Elsinore. The prospects of a considerable goods traffic for the new steam ferries are considered favorable, and this for several reasons. The turnover between the two countries is considerable, and is steadily and rapidly rising; the exports from Germany to Sweden were $45,000,000 value for the year 1906, against about $12,500,000 in 1880, and the exports from Sweden to Germany rose during the same period from a value of barely $3,500,000 to $37,500,000. Among the more likely articles for the steam-ferry traffic are provisions, butter, meat, and milk, building material, such as stone and chamotte, manufactured wood, etc., as far as Sweden is concerned; and chemicals, coal, coke, salt, feeding stuffs, machinery, etc., on the part of Germany. It is pointed out that, in order duly to develop the commercial intercourse between two countries so close together as Sweden and Germany, the quickest, most convenient, and most regular freight service arrangements are essential. The Trelleborg-Sassnitz steamer connection, as hitherto carried on, was so inadequate, as far as goods traffic was concerned, that during the year 1905 no less than two and a half times as much traffic was sent from Sweden and Norway to Germany through Denmark, rather than *via* Trelleborg-Sassnitz, and for goods from Germany to Sweden and Norway the proportion was still more strikingly in favor of the steam ferry—viz., more than eight times more than by way of Sassnitz-Trelleborg. The new Trelleborg-Sassnitz steam ferry, it is confidently asserted, will be of very great advantage to the goods traffic between the two countries, and is bound to prove a great boon to both countries. It is essential, however, that everything should be done to make the service as expeditious as possible, with the avoidance of all unnecessary delay at the terminal stations, by simplification of the routine, etc. The following table shows the increase of the Gedser-Warnemünde steam-ferry traffic:

	From Germany to Denmark.	From Denmark to Germany.
Nov. 1, 1903, to Mar. 31, 1904	20,375	6,425
Apr. 1, 1904, to Mar. 31, 1905	61,058	19,476
Apr. 1, 1905, to Mar. 31, 1906	67,079	23,405

The goods traffic on the Malmö-Copenhagen steam-ferries has also materially increased of late years, and in America, too, steam-ferries have tended greatly to increase traffic. The passenger traffic also favors the steam-ferry connection; the traffic *via* Trelleborg-Sassnitz from the Swedish State railways increased 29 per cent from 1901 to 1905, while the increase of passengers from the Swedish State railways *via* Denmark to Germany, etc., was 61 per cent during the same period.

The question as to between which places the new connection should be established was most carefully considered. As far as Sweden was concerned, there were three places: Malmö, Trelleborg, and Ystad. The Malmö harbor, however, on account of its position, is only suitable for goods ferry traffic, preferably to Warnemünde, so it was really out of the question. The Ystad harbor could be made to accommodate a steam-ferry traffic; but this place is not favorably situated, as far as railway communications are concerned, and would necessitate the purchase of too many private railways. Trelleborg, on the other hand, had several advantages.

Retaining Trelleborg as the Swedish terminus for the connection between the two countries, it was natural to fix upon Sassnitz as the German terminus; but several objections were made to the latter, and some other places were under consideration—viz., Zingst, Barhöft, and Arcona. The Prussian authorities maintained, however, that they were indisposed to go in for new expensive harbor and railway construction at other places until Sassnitz had actually been proved ill-fitted for the purpose, the more so as considerable time would have to elapse before new installations elsewhere would be ready for use. The conditions of the coast at Barhöft were considered unfavorable; the newly-deepened inlet, some 6 miles long, which has two bends, could only be traversed at a reduced speed, and stormy or foggy weather would interfere with the regularity of the service. The cost of making Hiddensee the terminus was of a prohibitive nature. At Arcona the natural conditions for constructing a harbor, and those of the coast generally, were better; but it was decidedly cheaper to alter the Sassnitz harbor so as to meet the requirements of the new traffic. There is reason to believe that Prussia ere long will improve the railway accommodation in the Island of Rügen and connect the latter with the Continent by means of a bridge, in the same way as railway improvements are likely to be made on the Swedish side. In case the accommodation at Sassnitz should by and by prove too limited, with a bridge built across the sound at Stralsund, no better place could probably be found than Arcona. It has, however, not been deemed advisable to wait for the establishment of the new steam-ferry connection until the best obtainable localities and accommodation were available, as it would probably take six years to construct a new harbor with railway connection, etc.

The dimensions of the ferry-boats are: Length on rail deck, 377 feet; greatest breadth, 53 feet; draft with load, about 17 feet. The dimensions of length and breadth allow of double sets of rails with an aggregate length of free railway line of 533 feet, so that eighteen goods wagons, or passenger or mail carriages of the same dimensions, can be taken on board at the same time, a bogie carriage for passengers' luggage or mail being reckoned equal to two two-axle goods wagons. The ferries have two propellers, and rudders fore and aft; they are constructed with a view of forcing their way through ice, and the coaches are to be taken on board only at the stern. Their displacement is about 4,200 tons, and the engines are 4,500 horse-power, giving a speed of 16 knots. There is ample accommodation both for passengers and crew, as well as suitable accommodation for post and customs officials.

The ferries on the Trelleborg-Sassnitz service are large, and in every respect fit for the comparatively long crossing. The problem was carefully considered, and it was found that some of the large American steam ferries seemed best to answer the requirements of the new route. It may not be out of place here to draw attention to the immense development of the steam-ferry traffic in America. Ten years ago American railways employed 197 ferries, with an aggregate capacity of 2,069 goods bogie-wagons; two years ago the number of ferries had increased to 562, and their aggregate capacity to 5,615 wagons. On Lake Michigan alone there are nine steam-ferry lines, and the establishment of others is contemplated. Recently the steam-ferry has been used to take through trains past Chicago, so as to avoid its busy stations. The Swedish railway authorities were especially impressed by the Père Marquette ferries, and the new Swedish ferries may be looked upon as a somewhat modified Père Marquette ferry. The speed has been increased from 14 to 16 knots, the length increased some 20 feet, and the breadth reduced some 3 feet, while the draft has been left about the same. The Swedish ferries are better looking, having more the appearance of an ocean liner. They have two decks above the rail deck—the lower for cabins and saloons, the upper for a promenade deck. Notwithstanding the regard paid to appearance and to thoroughly up-to-date accommodation for the passengers, the new ferries are confidently expected to be good sea boats, and also capable of making their way through fairly substantial ice.

The Trelleborg harbor has been extended, and the inlet deepened to 23 feet, and in some places to 25 feet. The channel has been widened to a breadth of 167 feet at the entrance, and from there gradually to twice that breadth at a distance of 3,880 feet. The outer portion of the harbor is to be deepened to 22 feet.

The Swedish-German ferry will probably bring about some long-contemplated improvements in the Danish Gedser-Warnemünde service—viz., a direct railway from Copenhagen to Köge—whereby the bend to Roskilde will be done away with, and the building of a bridge at Orchaved across the Masned Sound, the cost of which is calculated at some $2,250,000. The new railway and the bridge, which would do away with the present Orchaved-Masnedö steam-ferry service, will result in a saving of three-quarters of an hour between Copenhagen and Berlin.

* Engineering.

Correspondence.

AN EASY WAY OF CASTING OUT THE 3'S.

To the Editor of SCIENTIFIC AMERICAN SUPPLEMENT:

I have discovered an easy way of casting out the 3's. It may be used in proving arithmetical work, and in finding quickly whether any given number is divisible by 3. As I have not seen it in any publication, I beg leave to set it forth in your columns, so that many teachers and mathematicians will see it; for it may be of use in their work.

RULE.

Pass the pencil over the given number, jumping every 0, 3, 6, or 9, and letting it touch every 1, 4, or 7 (straight-stroke figure) once at the bottom, and every 2, 5, or 8 once on the front edge near the bottom and once on the back edge near the bottom.

Add one each time the pencil touches, saying 1, 2, 3; 1, 2, 3, etc.

If the last count be 3, the number is divisible by 3, and the excess is 0. Otherwise, the last count (1 or 2) is the excess, or the remainder when the number is divided by 3.

EXAMPLES.

	3	0	6	9	1	4	7	2	5	8	÷ 3
					1	2	3	1 2	3 1	2 3	leaves 0.
	1	0	3	8	6	7	2	4	5	7	÷ 3
	1			2 3		1	2 3	1	2 3	1	leaves 1.
8	5	1	7	9	0	2	3	8	9	1	÷ 3
1 2	3 1	2	3			1 2		3 1		2	leaves 2.

THE REASON.

It has long been known that to add the digits of any number and divide their sum by 9 or 3 leaves the same remainder as to divide the number itself by 9 or by 3 respectively. The new method does away with the labor of adding the digits, and simply provides a plan by which the 3's may be counted out of the excesses.

0, 3, 6, or 9 ÷ 3 leaves 0.
1, 4, or 7 ÷ 3 leaves 1.
2, 5, or 8 ÷ 3 leaves 2.

A SHORTER METHOD.

For convenience touch the figures at or near the bottom. Always touch the same digits at the same points, until these points become so thoroughly fixed in the mind that there will be no hesitation and no mistake. After that the calculator may touch only every third point to be counted, and think 3, 3, 3, until he comes to the close of the number, when he must take note of the final excess, whether this be 0, 1, or 2.

EXAMPLES.

			1	4	7	2	5	8		
					3		3	3		
	1	0	3	8	6	7	2	4	5	7
				3			3		3	1
8	5	1	7	9	0	2	3	8	9	1
	3		3					3 1		2

GROUPING THE FIGURES.

There are three series of figures; (1) the 0369 series, (2) the 147 series, and (3) the 258 series.

Any number or portion of a number, consisting of two figures, is divisible by 3:

(1) If both figures belong to the 0369 series, as 36 or 99.

(2) Or if one figure belongs to the 147 series and the other to the 258 series, as 45 or 84.

But no number or portion of a number, consisting of two figures, is divisible by 3:

(1) If both figures belong to the 147 series, as 47 or 71.

(2) If both figures belong to the 258 series, as 52 or 88.

(3) Or if one figure belongs to the 0369 series and the other figure to either of the other series, as 31 or 89.

Any number or portion of a number, consisting of three figures, is divisible by 3:

(1) If the three figures are all alike, as 555 or 777.

(2) If the three figures all belong to the same series, as 369, 714 or 852.

(3) Of if one figure is taken from each series, as 312, 978 or 405.

But no number or portion of a number, consisting of three figures, is divisible by 3, if the figures belong to two, and only two, of the series, as 367, 974, or 805.

FACTORING.

The expert accountant would soon become able to pass over a zero-producing group of figures, like 75 or 258, without touching and without counting almost as readily as he would pass over 6 or 9.

Consequently, he could tell, almost at a glance, whether any given number less than a million is divisible by 3 or not, and this would often help him in factoring, cancelation, and the reduction of fractions to their lowest terms.

PROVING WORK.

It is not necessary for me to take up your valuable space in showing how arithmetical work may be proven by casting out the 3's. Anyone who understands how to cast out the 9's will be able to apply this method in testing his calculations. It will take some practice to become quick and accurate in its use, but the saving of time and labor will justify the effort.

G. W. WISHARD.

New York.

A VISIT TO AN ANTHRACITE COAL MINE.*

By WARREN O. ROGERS.

IT was the writer's good fortune to obtain permission from F. M. Zerbey, general manager of the Kingston Coal Company, to visit the Edwardsville, No. 4, mine of the company. The descent was made in company with the mine superintendent, Thomas H. Williams, Master Mechanic Erskin L. Solomon and Mine Foreman Thomas Martin. The first stop was made at the 350-level.

One unaccustomed to the skill with which the hoisting engineer handles his engines cannot fail to note the accuracy with which the cage is stopped at each level for the loading and unloading of coal cars hundreds of feet below the surface of the earth.

One would naturally expect that at such a depth considerable water would be encountered, but such was not the case. The miners can tell, however, in the upper veins within a few hours that a rain storm has set in, by noting the water trickling down the side walls of the gangways of the levels upon which they are working. This water is taken care of by directing it to the sump from which it is pumped to the surface, or if the pump it located at an extreme depth, the water is delivered to a pump placed on a higher level, which in turn delivers the water to the surface. These pumps are scattered through the mine, and on different levels, the steam being piped to them from a boiler plant above ground, and the steam pipes led to the underground working down the shaft.

Close to the shaft is located the hospital where the injured men are taken, to receive first aid, there being a medicine locker containing such supplies as will be required under ordinary circumstances, after which the sufferer is hoisted to the surface where an ambulance is waiting to convey him to the hospital. The ambulance is always near by, the law compelling every mine to have one stationed within 500 feet of the mine shaft.

Before starting out into the workings of a level, a report sheet is inspected. This report sheet has a record showing the gaseous condition of the workings, stating whether each is clear or not; and if not, to what extent gas is present, or at what time it was cleared.

An average man requires about 900 cubic inches of air per minute when at rest, and 1,500 cubic inches when exerting himself under ordinary conditions. Coal mining is a far more strenuous exercise than walking, and the amount of air required for a miner is therefore greater, or about 1,728 cubic inches per minute. Thus it is important that a mine be thoroughly ventilated, even if the matter of safety were eliminated altogether. Owing to the varying amount of gas found in a mine, the problem of calculating the quantity of air necessary to keep the mine in a safe condition is most difficult. It has been found that 100 cubic feet of air per minute per man employed in a mine which is free from gas is sufficient. If the mine is moderately gaseous, 250 cubic feet of air per minute is required, and if the mine is considerably gaseous, from 450 (minimum allowed by law) to 500 cubic feet per minute per man employed.

Gas is detected by the effect it has on the safety lamp carried by the inspector. Owing to its lightness, it is always found in the highest part of the mine, and is not easily detected in all cases. If gas is present in small quantities the flame of the safety lamp will flicker slightly vertically; in larger quantities the flame will become enlarged and considerably longer and a blue halo will surround it; it requires considerable skill to detect small amounts of gas.

The method of disposing of the gas is by proper ventilation. This is accomplished by forcing sufficient air into the mine by means of fans, so that the gases are diffused and the workings put in a proper condition for the miners.

As we made our passage along a level on the way to a face working, or where the miners were working at the extreme end of an excavation, cutting coal, doors were encountered which completely shut off a portion of the passage in order to force air to the face of the drift. These doors hung so that they would swing shut without aid, thus forming an automatic protection against the carelessness of any workman should he forget to shut a door after passing through. These doors were necessary, as without them the air current would naturally take the shortest cut to the upcast and, consequently, the workings farthest from the down-cast shaft, where the air is forced into the mine, would suffer from lack of proper ventilation.

As the face of the working was neared, a canvas cloth was found hanging across the air passage. This was because a blast had just been fired, and as the air current was rather weak at that particular place the canvas helped to conduct the air to the face, created a slightly increased draft, and so cleared the working of smoke and gas.

Passing from the face working, a visit was made to the stables, 1,000 feet underground. Here the mine mules were stabled, and contrary to what one would naturally expect, the place was kept as clean and as sweet as most stables found on the surface. This is accomplished by the free use of whitewash and the fact that the partitions between the stalls are made of sheet iron; which is not only a sanitary arrangement but also a safeguard against fire.

Slightly more than 1 per cent of the men employed in or about the mines in the United States are either killed or injured each year; and as more are injured and killed due to falling slate and the caving in of the sides of the chambers than are hurt and killed by explosions, it is evident that the matter of timbering a mine is of great importance.

Drives follow the inclination of the coal seams, the roof being supported by timbering of some kind. This is not only to support the roof when it is in bad condition, but to keep a good roof sound. In the working places timbering is set at stated intervals. The props used in the side timbering are subjected to a compression strain, and their length being about ten or twelve times their diameter a prop so proportioned will support about $1\frac{1}{2}$ tons per square inch; a prop 12 inches in diameter has an area of $12 \times 12 \times 0.7854 = 113$ square inches, and a breaking strain of $113 \times 1.5 = 169$ tons. It would seem that such a crushing strain would not be exerted on any one timber, yet the writer recently saw a large number of southern pine timbering, ranging from 10 to 24 inches in diameter, broken and shattered. In one instance a timber of southern pine, all of 24 inches in diameter, was splintered at the top by the enormous weight of roof, which, according to the figures given, must have been in excess of 338 tons exerted as a crushing strain. This timbering had been in place less than three months, and was used in reinforcing the roof supports overtaxed by a squeeze.

Before a squeeze occurs, warning is generally given by various noises which, if heard, enable the mine foreman to place new timbering to support the roof and sides. Frequently, however, the pressure on the old timbering becomes so great that the squeeze occurs despite the skillful efforts on the part of those in charge. When this occurs it means that the débris must be removed and new timbering put in place before that section of the mine can be worked again.

In No. 4 mine, southern pine timber is used exclusively, it being considered the best timbering wood procurable. In some instances the largest timber measured over 24 inches in diameter and the others very close to 20 inches.

Timbering a mine is expensive. If southern pine is used for the purpose, the cost and treatment will amount to about 11 cents per cubic foot of coal mined. Wood timbering is treacherous, as oak, beech, and similar hardwoods, while having great strength, will suddenly fail without warning, while yellow pine such as is used in the mine mentioned fails more slowly.

A new departure in timbering mines that is rapidly taking the place of wood in many of the newer mines, is the use of steel. In 1878, attempts were made in France to use old rails as head pieces, and in the United States rails have been used for some years. To-day special steel sections are made expressly for mine timbering.

* Power and the Engineer.

The paper by Prof. Henry Adams read to the Association of Engineers-in-Charge is of distinct educational value, and is admirably illustrated by a number of well-drawn diagrams. In the early part of this communication the author refers to the inappropriate use formerly made of the term "strains" to denote effects which engineers to-day invariably describe as "stresses." It is well that the distinction should be clearly understood by all who have to deal with the design of structures. One other distinction suggested to us as desirable by a remark in the paper to which we now refer is the difference between pure shear and the tension on diagonal planes resulting from the combination of shear and the stresses due to bending moment. Until quite recently it has been the custom for engineers and others to speak of shear as a frequent cause of failure in reinforced concrete beams when designed without adequate web reinforcement. To-day, however, it is known that the shearing strength of concrete is proportionately so large as to make failure in shear quite an exceptional circumstance, the fact being that most failures of the kind so denoted were really due to tension on diagonal planes. That being so, it is better that the phrase "failure in shear" should be strictly reserved for application to cases where shearing force alone is the actual cause of rupture.

A NOVEL LETTER-COPYING MACHINE.

THE SOLUTION OF THE PROBLEM OF MOIST COPIES.

BY THE GERMAN CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

One drawback to the use of the letter-copying machines so far in use has been the necessity of moistening the copies. Such drying devices, on the other hand, as have been constructed are nothing but ordinary drums on which the roll of copied paper is wound up, to dry in the air. These devices can be used only as provisional receivers of wet copies, from which a copy required for reference cannot be immediately cut.

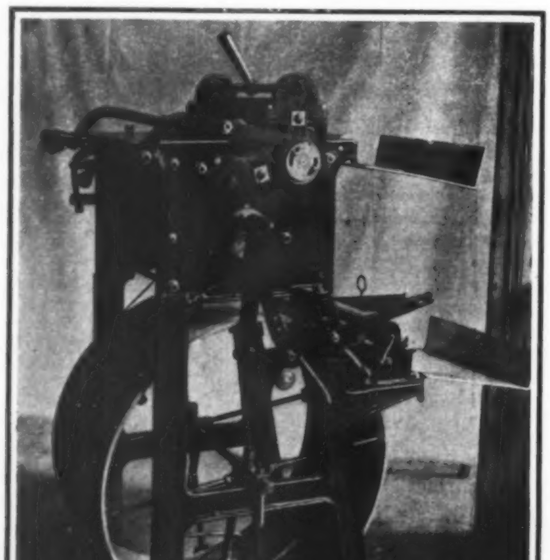
A copying machine recently constructed by Max Kluge of Breslau, Germany, is intended to eliminate this inconvenience, the copies being delivered in a perfectly dry condition, owing to an ingenious automatic drying attachment of patented construction.

This drying attachment comprises a big drum with a hollow metal sleeve carrying in its exterior a layer of blotting paper and filled with about one quart of water to approximately one-third of its diameter. The drum is heated by a Bunsen burner acting on its inner surface from above downward. Because of the rotation of the drum the whole metal sleeve is heated uniformly, the paper drying so rapidly that it is restored to its original condition durińg the few seconds in which it runs over the drum. Swelling and scorching of the paper is entirely excluded, the heat supply to the outside metal sleeve being transmitted through the water layer. A supply of water suffices for about a week if the attachment is daily used.

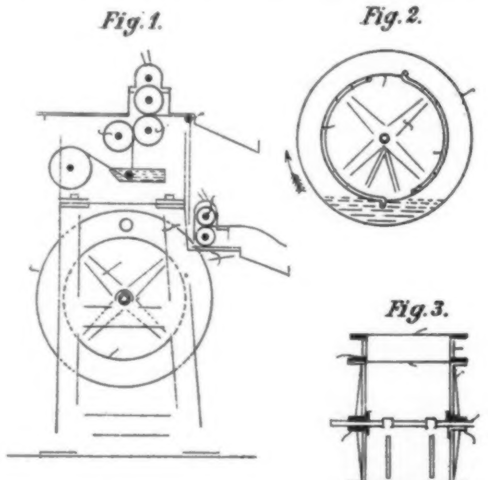
The machine is operated by a crank. After every three revolutions an automatic cutting device is actuated, which cuts the paper accurately to the desired length. By simply pressing a lever down, this device can be thrown out of gear with a view to producing double sheets, etc.

An ingenious device has been provided for stamping the original letters with the word "Copied." This device comprises four stamps actuated by special hand levers, each of which stamps is used in connection with one of the four usual sizes. This device likewise saves time and labor.

The above-described copying machine is operated in exactly the same manner (through crank and eccentric) as ordinary quick-copying machines, the speed being also the same, as the path traversed by the copies on the drying drum is not greater than in the case of the drying devices of other machines.



A NOVEL LETTER-COPYING MACHINE.



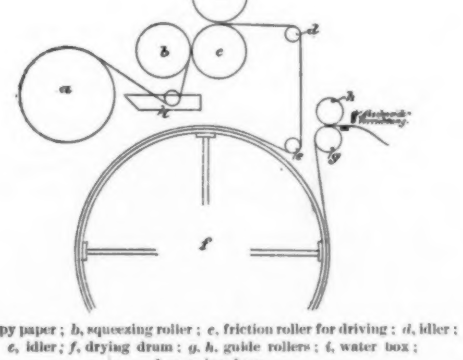
A MACHINE FOR DRYING WET COPIES OF LETTERS.

The Chungking Electric Light Company, a Chinese company, started operations on a small scale in June, 1908. It is running 220 lamps of 16 candle-power each, and the dynamo is driven by a 5-inch belt from a small vertical engine of about 22 horse-power. The company is now considering tenders from various firms for the erection of a big plant to light the whole city, and a piece of ground has been bought outside the Tai Ping Men on which to erect the plant.

THE MARINE GAS ENGINE.

We all know the saying that if a falsehood is given a small start the truth will never catch it up. That observation was no doubt based originally on the works of the slander-monger, and its truth in most cases has been confirmed times out of mind. In a very different field the same sort of thing occurs. Once lead the public to believe that a certain thing—about which their own ignorance is colossal—is going to occur, and nothing but the repeated failure of the phenomenon to appear will convince them they are wrong. Expert opinion is arraigned in vain; men eminent in their professions demonstrate the impossibility of the thing expected; books, papers, pamphlets, articles, hold forth against it, and though for a time the ghost is laid, he comes up again as merrily as ever on the slightest encouragement. Engineering could show many examples of this sanguine and credulous temperament of the general public. None, in recent times at least, can surpass that which the gas engine ship presents. Two years ago an authority on such subjects ventured to lift the veil of the future and drew a picture of a funnelless battleship propelled by suction gas engines. Ever since, whenever a new lot of vessels has been laid down, the statement has been circulated in one paper or another that the ship of dreams was about to be realized. It has even been hinted that one of the enormous White Star liners now on the stocks would be propelled by internal-combustion engines, and—the point is one the public never forgets—she would have no funnels.

The trained engineer is, of course, not led astray by these wild fancies; he knows well enough that in mechanical engineering there are no sudden jumps from the small to the great, and he is aware that before the gas Atlantic liner plies between Liverpool and New York many a smaller boat must bring the type step by step through its stages of evolution; but even he, unless he has made a study of the subject, is not aware that we are still a long way, a very long way, from the gas-ship of even moderate size; and he is probably still more unaware that the apparent advantages of the internal-combustion engine for ship propulsion do not in fact exist. Take, for example, the question of weight. It seems incredible that an engine without boilers should weigh nearly as much per horse-power as an engine with them. Yet it is a fact that many designers have found this absolutely true when departure is made from quite moderate powers. There are many things that contribute to this apparently anomalous result. In the remarkable paper which he presented at the last meeting of the Institution of Naval Architects, Lieut. Anstey, premising that "the weight of the engine is proportional to the maximum pressure for which the engine has to be designed," estimates that the weight of an internal-combustion engine per horse-power was nearly three and a quarter times that of a steam engine. That was considered from the point of view of pressure alone, and certain deductions have to be made which work out in favor of the internal-combustion engine, but even then, according to Lieut. Anstey, the ratio does not descend below about 2 or 2½ to 1. Then, though it is true that many auxiliaries which are not required by the internal-combustion engine have to be set against the steam engine, it is a fact, on the other hand, that the gas or oil engine for marine work must be provided with means for reversal which, be they either a clutch or an air compressor and reservoir, run into a surprising amount of weight. Furthermore, if the engine is to use gas, the generators have to be taken into account, and they are estimated to weigh as much as the boilers. Without going step by step through all the calculations it would be impossible to show how the weights are made up,



a, copy paper; *b*, squeezing roller; *c*, friction roller for driving; *d*, idler; *e*, idler; *f*, drying drum; *g*, *h*, guide rollers; *i*, water box; *k*, copying drum.

but we have it on the testimony of an engineer and shipbuilder who has experimented on a large scale, and devoted much time to the problem, that for engines in the neighborhood of over 1,000 horse-power there is no appreciable saving in weight; indeed, Lieut. Anstey himself, after reviewing all the items, concludes: "It appears certain that if the internal-combustion engine is to develop on lines parallel to that of the steam engine—that is, with few cylinders—there will be no very great saving, such as has sometimes been imagined by inference from the results obtained with small-sized units, when the speed of revolution is high." In the matter of space there is no doubt some advantage, but it is doubtful if full allowance has been made for the numerous accessories and auxiliaries which form part of every ship, and are dependent in the steamer on the main boilers. Take, for example, such things as pumps—other than feed—

fresh water evaporators, steering gear, winches, refrigerating machinery, and so on. Each of these now draws its supply of steam from the main generators. How are they to be worked in a gas or oil engine ship? Evaporators might use the exhaust from the engines, but what of the steering gear and refrigerating machinery? They must have their own boiler plant, or they must be driven in some other way, say electrically; but in either case it is doubtful if they can be run with so little weight per unit of power as under the present circumstances. Then as to those chimneys! Is it forgotten that the gas engine has products of combustion that must be got rid of, and that if they are to be disposed of noiselessly they must leave at a low velocity? In other words, that a big funnel will be required? It is said that they will be discharged below the water level. That may do for quite small powers. We doubt if it would be found practicable in a liner or a battleship.

However we may look at it, it is abundantly clear that in its present state the internal-combustion engine cannot be applied to ship propulsion except in small units, and much water will flow under the bridges before the funnelless gas ship will be an accomplished fact. The directions in which progress is to be sought are pretty clear, but it may be useful to indicate them. First, the power per unit of cylinder must be increased. The largest land engines of the present day are all horizontal, and not sufficient experience has been gained with vertical engines of large power to warrant anyone placing them in a position where trustworthiness is of such absolute importance as the main engines of a ship. Secondly, the increase of the number of cylinders which can be got to work together must be sought by careful investigation and steady progress. It may seem a simple matter to add another cylinder or two, but everyone who has worked with multiple-cylinder engines is aware that it is not the easiest thing possible to insure that each one does its share of the work. Thirdly—and though we put this last, it controls the situation—a satisfactory solution of the problem of reversing the engine must be found. That these things can be accomplished we do not doubt, but years of work and step-by-step progress must precede success, and we are as convinced as one may be of anything in this world of surprises that the gas battleship will not figure in the naval estimates for many years to come.—The Engineer.

CANNING AND PRESERVING FRUIT.—II.*

HINTS FOR THE HOUSEWIFE.

BY MARIA PARLOA.

Continued from Supplement No. 1753, page 95.

UTENSILS NEEDED FOR CANNING AND PRESERVING.

In preserving, canning, and jelly making iron or tin utensils should never be used. The fruit acids attack these metals and so give a bad color and metallic taste to the products. The preserving kettles should be porcelain lined, enameled, or of a metal that will

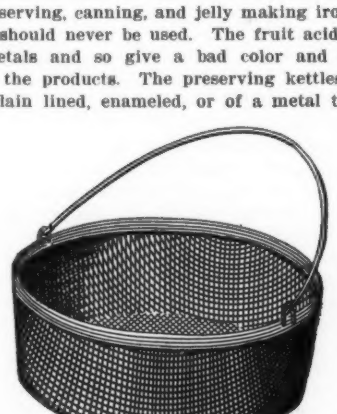


Fig. 1.—WIRE BASKET.

not form troublesome chemical combinations with fruit juices. The kettles should be broad rather than deep, as the fruit should not be cooked in deep layers. Nearly all the necessary utensils may be found in some ware not subject to chemical action. A list of the most essential articles follows:

Two preserving kettles, 1 colander, 1 fine strainer, 1 skimmer, 1 ladle, 1 large-mouthed funnel, 1 wire frying basket, 1 wire sieve, 4 long-handled wooden spoons, 1 wooden masher, a few large pans, knives for paring fruit (plated if possible), flat-bottomed clothes boiler, wooden or willow rack to put in the bottom of the boiler, iron tripod or ring, squares of cheese cloth. In addition, it would be well to have a flannel straining bag, a frame on which to hang the bag, a syrup gage and a glass cylinder, a fruit pricker, and plenty of clean towels.

The regular kitchen pans will answer for holding and washing the fruit. Mixing bowls and stone crocks can be used for holding the fruit juice and pared fruit. When fruit is to be plunged into boiling water for a few minutes before paring, the ordinary stewpans may be employed for this purpose.

Scales are a desirable article in every kitchen, as weighing is much more accurate than the ordinary measuring. But, knowing that a large percentage of

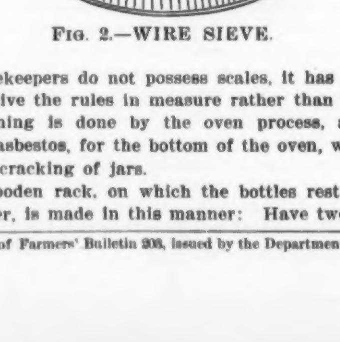


Fig. 2.—WIRE SIEVE.

the housekeepers do not possess scales, it has seemed wise to give the rules in measure rather than weight.

If canning is done by the oven process, a large sheet of asbestos, for the bottom of the oven, will prevent the cracking of jars.

The wooden rack, on which the bottles rest in the washboiler, is made in this manner: Have two strips of wood measuring 1 inch high, 1 inch wide, and 2 inches shorter than the length of the boiler. On these pieces of wood tack thin strips of wood that are 1½ inches shorter than the width of the boiler. These cross-strips should be about 1 inch wide, and there should be an inch between two strips. This rack will support the jars and will admit the free circulation of boiling water about them. Young willow branches, woven into a mat, also make a good bed.

The wire basket is a saver of time and strength (Fig. 1). The fruit to be peeled is put into the basket, which is lowered into a deep kettle partially filled with boiling water. After a few minutes the basket is lifted from the boiling water, plunged for a moment into cold water, and the fruit is ready to have the skin drawn off.

A strong wire sieve is a necessity when purees of fruit are to be made (Fig. 2). These sieves are known as puree sieves. They are made of strong wire and in addition have supports of still stronger wire.

A fruit pricker is easily made and saves time (Fig. 3). Cut a piece half an inch deep from a broad cork; press through this a dozen or more coarse darning needles; tack the cork on a piece of board. Strike the fruit on the bed of needles, and you have a dozen holes at once. When the work is finished, remove the cork from the board, wash and dry thoroughly. A little oil on the needles will prevent rusting. With needles of the size suggested there is little danger of the points

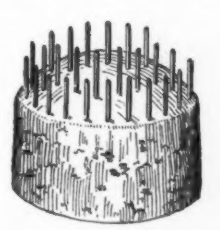


Fig. 3.—FRUIT PRICKER.

breaking, but it is worth remembering that the use of pricking machines was abandoned in curing prunes on a commercial scale in California because the steel needles broke and remained in the fruit.

A wooden vegetable masher is indispensable when making jellies and purees (Fig. 4).

A syrup gage and glass cylinder (Fig. 5 *A* and *B*) are not essential to preserving, canning, and jelly making, but they are valuable aids in getting the right proportion of sugar for fruit or jelly. The syrup gage costs about 50 cents and the cylinder about 25 cents. A lipped cylinder that holds a little over a gill is the best size.

Small iron rings, such as sometimes come off the hub of cart wheels, may be used instead of a tripod for slightly raising the preserving kettles from the hot stove or range.

To make a flannel straining bag, take a square piece of flannel (27 by 27 inches is a good size), fold it to make a three-cornered bag, stitch one of the sides, cut the top square across, bind the opening with strong, broad tape, stitch on this binding four tapes with which to tie the bag to a frame.

To use this bag, tie it to a strong frame or to the backs of two kitchen chairs. If the chairs are used, place some heavy articles in them; or the bag may hang on a pole (a broom handle) which rests on the backs of the chairs. A high stool turned upside down makes a good support for the bag. Put a bowl on the floor under the bag, then pour in the fruit juice, which will pass through comparatively clear.

Before it is used the bag should be washed and boiled in clear water.

SELECTION AND PREPARATION OF THE FRUIT.

The selection of fruit is one of the first steps in ob-

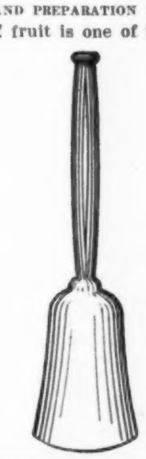
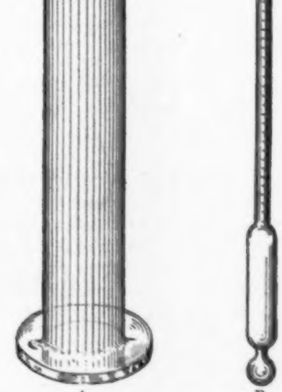


Fig. 4.—WOODEN VEGETABLE MASHER.

taining successful results. The flavor of fruit is not developed until it is fully ripe, but the time at which the fruit is at its best for canning, jelly making, etc., is just before it is perfectly ripe. In all soft fruits the fermentative stage follows closely upon the perfectly ripe stage; therefore it is better to use under-ripe rather than over-ripe fruit. This is especially important in jelly making for another reason also: In over-ripe fruit the pectin begins to lose its jelly-making quality.

All fruits should, if possible, be freshly picked for preserving, canning, and jelly making. No imperfect



A B

Fig. 5.—GLASS CYLINDER (A) AND SYRUP GAGE (B).

fruit should be canned or preserved. Gnarly fruit may be used for jellies or marmalades by cutting out defective portions. Bruised spots should be cut out of peaches and pears. In selecting small-seeded fruits, like berries, for canning, those having a small proportion of seed to pulp should be chosen. In dry seasons

* Reprint of Farmers' Bulletin 203, issued by the Department of Agriculture.

berries have a larger proportion of seeds to pulp than in a wet or normal season, and it is not wise to can or preserve such fruit unless the seeds are removed. The fruit should be rubbed through a sieve that is fine enough to keep back the seeds. The strained pulp can be preserved as a puree or marmalade.

When fruit is brought into the house put it where it will keep cool and crisp until you are ready to use it.

The preparation of fruit for the various processes of preserving is the second important step. System will do much to lighten the work.

Begin by having the kitchen swept and dusted thoroughly, that there need not be a large number of mold spores floating about. Dust with a damp cloth. Have plenty of hot water and pans in which jars and utensils may be sterilized. Have at hand all necessary utensils, towels, sugar, etc.

Prepare only as much fruit as can be cooked while it still retains its color and crispness. Before beginning to pare fruit have some syrup ready, if that is to be used, or if sugar is to be added to the fruit have it weighed or measured.

Decide upon the amount of fruit you will cook at one time, then have two bowls—one for the sugar and one for the fruit—that will hold just the quantity of each. As the fruit is pared or hulled, as the case may be, drop it into its measuring bowl. When the measure is full put the fruit and sugar in the preserving kettle. While this is cooking another measure may be prepared and put in the second preserving kettle. In this way the fruit is cooked quickly and put in the jars and sealed at once, leaving the pans ready to sterilize another set of jars.

If the fruit is to be preserved or canned with syrup, it may be put into the jars as fast as it is prepared. As soon as a jar is full, pour in enough syrup to cover it.

If several people are helping and large kettles are being used for the preserving, or where fruit (like quinces and hard pears) must be first boiled in clear water, the pared fruit should be dropped into a bowl of cold water made slightly acid with lemon juice (one tablespoonful of lemon juice to a quart of water). This will keep the fruit white.

All large, hard fruit must be washed before paring. Quinces should be rubbed with a coarse towel before they are washed.

If berries must be washed, do the work before stemming or hulling them. The best way to wash berries is to put a small quantity into a colander and pour cold water over them; then turn them on a sieve to drain. All this work must be done quickly that the fruit may not absorb much water.

Do not use the fingers for hulling strawberries. A simple huller can be bought for five cents.

If practicable pare fruit with a silver knife, so as not to stain or darken the product. The quickest and easiest way to peel peaches is to drop them into boiling water for a few minutes. Have a deep kettle a little more than half full of boiling water; fill a wire basket with peaches; put a long-handled spoon under the handle of the basket and lower into the boiling water. At the end of three minutes lift the basket out by slipping the spoon under the handle. Plunge the basket for a moment into a pan of cold water. Let the peaches drain a minute, then peel. Plums and tomatoes may be peeled in the same manner.

If the peaches are to be canned in syrup, put them at once into the sterilized jars. They may be canned whole or in halves. If in halves, remove nearly all the stones or pits. For the sake of the flavor, a few stones should be put in each jar.

When preparing cherries, plums, or crab apples for canning or preserving, the stem or a part of it may be left on the fruit.

When preparing to make jelly have ready the cheesecloth strainer, enameled colander, wooden spoons, vegetable masher, measures, tumblers, preserving kettles, and sugar.

If currant jelly is to be made, free the fruit from leaves and large stems. If the jelly is to be made from any of the other small fruits, the stems and hulls must be removed.

When the jelly is to be made from any of the large fruits the important part of the preparation is to have the fruit washed clean, then to remove the stem and the blossom end. Nearly all the large fruits are better for having the skin left on. Apples and pears need not be cored. There is so much gummy substance in There are several methods of measuring the proportion in making fine jelly.

MAKING SYRUP FOR USE IN CANNING AND PRESERVING.

Such syrups as are used in canning and preserving are made with varying proportions of water and sugar. When the proportion of sugar is large and that of the water small the syrup is said to be heavy. When the water predominates the syrup is light.

There are several methods of measuring the proportion of sugar in a syrup. The most scientific and accurate is with the syrup gage. Careful measurement or weighing is, however, quite satisfactory for all ordinary work if the syrup need not be boiled a long time. In boiling the water evaporates and the syrup grows thicker and richer. The amount of evaporation depends upon the surface exposed and the pressure of the atmosphere. For example, if a large quantity of syrup is boiled in a deep kettle the evaporation will not be rapid. If the same quantity of syrup were boiled the same length of time in a broad, shallow kettle the water would evaporate more rapidly and the syrup would be thicker and heavier. If a given quantity of syrup were boiled the same length of time in a high altitude, Colorado for example, and at the sea level, it would be found that the syrup boiled at the sea level would be thicker and less in volume than that boiled in Colorado. From this it will be seen that it is difficult to say what proportion of sugar a syrup will contain after it has been boiling ten or more minutes. Of course by the use of the syrup gage the proportion of sugar in a syrup may be ascertained at any stage of the boiling. After all, however, it is possible to measure sugar and water so that you can know the percentage of sugar when the syrup begins to boil. The following statement gives the percentage of sugar at the time when the syrup has been boiling one minute and also what kind of syrup is suitable for the various kinds of fruit:

One pint of sugar and 1 gill of water gives syrup of 40 deg. density: Use for preserved strawberries and cherries.

One pint sugar and one-half pint water gives syrup of 32 deg. density.

One pint sugar and 3 gills water gives syrup of 28 deg. density: Use either this or the preceding for preserved peaches, plums, quinces, currants, etc.

One pint sugar and 1 pint water gives syrup of 24 deg. density: Use for canned acid fruits.

One pint sugar and 1½ pints water gives syrup of 17 deg. density.

One pint sugar and 2 pints water gives syrup of 14 deg. density: Use either of these two light syrups for canned pears, peaches, sweet plums, and cherries, raspberries, blueberries, and blackberries.

The lightest syrups may be used for filling up the jars after they are taken from the oven or boiler. The process of making a syrup is very simple, but there are a few points that must be observed if syrup and fruit are to be perfect. Put the sugar and water in the saucepan and stir on the stove until all the sugar is dissolved. Heat slowly to the boiling point and boil gently without stirring. The length of time that the syrup should boil will depend upon how rich it is to be. All syrups are better for boiling from ten to thirty minutes. If rich syrups are boiled hard, jarred, or stirred they are apt to crystallize. The syrup may be made a day or two in advance of canning time. The light syrups will not keep long unless sealed, but the heavy syrups keep well if covered well.

Use of the Syrup Gage.

The syrup gage is a graduated glass tube, with a weighted bulb, that registers from 0 deg. to 50 deg., and that is employed to determine the quantity of sugar contained in a syrup.

If this gage is placed in pure water the bulb will rest on the bottom of the cylinder or other container. If sugar be dissolved in the water the gage will begin to float. The more sugar there is dissolved in the water the higher the gage will rise. In making tests it is estimated that the syrup should be deep enough to reach the zero point of the gage. If a glass cylinder holding about half a gill is filled to about two-thirds its height, and the gage is then placed in the cylinder, the quantity of sugar in the syrup will be registered on the gage.

Experiments have demonstrated that when sugar is dissolved and heated in fruit juice, if the syrup gage registers 25 deg., the proportion of sugar is exactly right for combining with the pectin bodies to make jelly. The syrup gage and the glass cylinder must both be heated gradually that the hot syrup may not break them. If the gage registers more than 25 deg., add a little more fruit juice. If, on the other hand, it registers less than 25 deg., add more sugar. In making syrups for canning and preserving fruits, the exact amount of sugar in a syrup may be ascertained at any stage of boiling, and the syrup be made heavier by adding sugar, or lighter by adding water, as the case demands.

(To be continued.)

THE TELEPHONE IN THEATRICAL MANAGEMENT.

It would appear that the applications of electricity, especially in the spectacular effects for illumination in those concentrations of human activities which we term the stage, had been carried to the point of exhaustion, yet the wonderful presentation of Schiller's play of Joan of Arc in the Harvard Stadium has added a new picture to the subject.

The seventeen hundred performers in that great amphitheater is considered the largest number ever appearing in the rendition of a scenic production, and the vast audience which nearly filled the seats, which have a capacity for twenty-one thousand, was certainly the greatest audience ever witnessing a theatrical production.

In this realistic succession of scenes of action depicting the career of the Maid of Orleans the distances were so magnificent as to be beyond the usual methods of theatrical management.

Although the actors and groups of supernumeraries were under the instruction of managers, yet there was even more of a necessity for a supreme head than on the usual boards. This was provided by a bower among other scenery in the middle of the amphitheater, where the stage manager and his immediate associates operated the lighting by means of the switches, by signal bells which gave instructions to others operating the switches in different parts of this great structure, and in addition to the greater uses of electricity there were a number of telephones reaching to those in management of different parts of the play.

As this great spectacle was without precedent, it is probably equally true that it will not be repeated on account of the lack of an amphitheater sufficient to give provision for the representation of these movements of armies on such an extended scale.—Electrical Review and Western Electrician.

THE USE AND ABUSE OF THE IONIC THEORY.*

By Gilbert Newton Lewis.

Twenty-five years have elapsed since Arrhenius advanced the theory that acids, bases, and salts in aqueous solution are dissociated into their constituent ions. Now that the storm of contention aroused by this doctrine is clearing, it may not be inappropriate to consider in cooler blood this proposition of Arrhenius, to reinspect the foundations, and to weigh without prejudice the pros and cons, the successes and failures of the ionic theory.

To show that an electrolyte in solution suffers a change analogous to dissociation, Arrhenius brought forward evidence of three different kinds. First, he pointed out that the various methods of determining molal concentration in solution (freezing-point, boiling-point, vapor pressure, osmotic pressure), all of which are identical in principle and yield nearly identical results, indicate that in a salt solution the number of molecules dissolved, or less hypothetically the number of mols, is greater than the number calculated from the simple chemical formula of the salt.

The second argument rests upon the observation that in an aqueous solution of a strong electrolyte the properties are purely additive. Thus a dilute solution of hydrochloric acid has no properties which are peculiarly its own. It tastes sour, turns litmus red, dissolves metals, inverts sugar, and possesses a number of other well-known properties, all of which are possessed in some degree by every acid. Moreover, it precipitates silver and mercurous salts, and exhibits other properties which are found in all chloride solutions. In other words, the solution has no properties which are not included in one of two distinct sets, one possessed by all acids, and one by all chlorides. So it seems natural to regard this solution as a mixture of two substances, hydrogen ion, which is present in all acids, and chloride ion, which is present in all chlorides. To illustrate this additive property let me perform this simple and familiar experiment. Here are two solutions in alcohol, one containing cobalt nitrate, the other an equivalent amount of cobalt chloride. One is red, the other a brilliant blue. On pouring these two into equal volumes of water, the difference in color disappears and both assume the pink color which is typical of aqueous cobalt solutions. Here again are three copper salts, nitrate, chloride, and bromide, which in alcohol are respectively blue, green, and dark brown, but when poured into equal volumes of water all show the same blue color of the cupric ion.

Finally, the third main argument in favor of ionization is derived from the electrical properties of solutions. Some fifty years ago Clausius believed that the conduction of electricity in electrolytes affords sufficient evidence to show a dissociation into ions. Whether or not we accept this proof, which is perhaps a little metaphysical, other experimental facts such as Kohlrausch's law of the additivity of conductivities at infinite dilutions, the agreement between conclusions drawn from conductivity and transference experiments, and the coincidence in the degree of dissociation calculated from conductivity and from freezing point, all give strong support to the theory of ionic dissociation.

Unfortunately, some over-enthusiastic advocates of the ionic theory, not content with this solid evidence, have superimposed on the theory other extraneous speculations which, when later discredited, have in some quarters brought the parent theory into disrepute. For example, I may mention the *dictum* that all chemical reactions in aqueous solutions are ionic in character, a notion which not only is intrinsically

* Address of chairman of the Section of Physical Chemistry, Baltimore.

improbable upon theoretical grounds, but has been refuted experimentally by the experiments of Kahlenberg and others. Some too zealous ionists have applied the theory to highly concentrated solutions, without making allowances for the deviations from the laws of the perfect solution which are to be expected there. It would be absurd to class as a dilute solution one which is five or ten times molal, yet we see attempts to apply to a pair such as sodium and potassium nitrates the law of solubility lowering which has been obtained for ideal solutions.

In justice to the author of the ionic theory, it should be noted that he has had no part in these attempts to stretch the theory beyond its elastic limit. In his papers on this subject, brief as they have been, Arrhenius has with great fairness and extraordinary acumen stated, as far as our present limited knowledge permits, the truth, the whole truth, and nothing but the truth about ionic dissociation.

Against the excess of zeal in some advocates of the theory may be balanced the dogmatism of others who for *a priori* reasons have declared it absurd that a substance like potassium chloride, bound together presumably by an enormous affinity, could break spontaneously into its constituent parts. Instead of attempting to refute such circular reasoning, let us return rather to the consideration of that experimental material upon which are based the three main arguments for the ionic theory. Here a careful scrutiny reveals facts which, disconcerting as they may be, no fair advocate of ionic dissociation can afford to ignore.

The first of these unpleasant facts is that the values for the degree of dissociation of strong electrolytes calculated on the one hand from freezing points, and on the other from conductivities, while usually fairly concordant, frequently differ by an amount far greater than the experimental error. For half normal solutions of lithium chloride, magnesium chloride and calcium ferrocyanide, the degrees of dissociation calculated from the freezing points are 94 per cent, 99 per cent and 2 per cent, while from conductivities we calculate 71 per cent, 62 per cent and 20 per cent, respectively. Of course these are moderately concentrated solutions and at higher dilutions the discrepancies become less. Moreover, it is not unlikely that the attempts to explain such facts, by assumptions of hydration, association, and the like, may ultimately be successful, but in the meantime these facts can not be neglected.

In the second place, the additivity of the properties of electrolytic solutions, striking as it is, seems to prove too much. If it is an argument for the dissociation of electrolytes, it seems to be an argument for complete dissociation. Why should the properties of a normal solution of potassium chloride be simply those of potassium and chloride ions if, as measurements of conductivity show, it is 25 per cent undissociated? Why should the undissociated part have no individual properties of its own? It is easy to see why completely dissociated acids and bases should give the same heat of neutralization, since we regard this heat as simply due to the union of hydrogen and hydroxide ions, but half-normal potassium and sodium hydroxides give essentially the same heat of neutralization with an acid, although they are 20 per cent undissociated. Half-normal barium hydroxide gives the same, although 40 per cent undissociated. Copper sulphate as dilute as one-tenth normal is still more than half undissociated, but its color is nearly the pure color of cupric ion. Indeed in all the strong electrolytes the partial volume, heat capacity, internal energy, viscosity, refractive index, rotary power, in fact practically all the significant physical properties of the undissociated part of the electrolyte, seem practically identical with the properties of the constituent ions. If we had no other criterion for the degree of dissociation, these facts would undoubtedly lead us to regard salts, up to a concentration of normal or half normal, as completely dissociated.

Finally, the phenomena of electrical conduction present several puzzling, and as yet unexplained, features. For example, attention has recently been called to the interesting fact that the two ions which in aqueous solution possess by far the greatest mobility, are the ions of water itself, hydrogen and hydroxide. This might possibly be regarded as chance if it had not also been found that in other solvents a similar condition exists. Thus in methyl alcohol, the methylate ion moves with unusual velocity. To explain this curious fact, it has been suggested that the ions of the solvent have a mode of progress different from that of other ions, due to their ability to pass virtually through the molecules of solvent. This view, in a certain sense, requires a return to a modified Grotthus theory, and if accepted, necessitates the conclusion that the process of conduction is not quite so simple as it may have seemed to the original advocates of the ionic theory.

Perhaps the most vulnerable point in the whole armor of the ionist is reached when we attempt to apply the mass law to the dissociation of strong electrolytes. The mass law derived rigorously only for the perfect solution could hardly be expected to be exactly true in the case of actual solutions. We might therefore expect certain small deviations from the mass law, but are in no way prepared for the startling discrepancies which are in fact observed. This discrepancy is sufficiently marked in the case of salts of the simplest type, like potassium nitrate or sodium chloride, but is most striking in the case of some salts of a higher type. The following table gives for three electrolytes the values of the "mass law constant" (*K*) at different molal concentrations (*C*). We see that when the concentration changes one thousand fold, *K* changes one hundred fold in the case of potassium chloride and one million fold in the case of potassium ferro-cyanide! For the weak electrolyte, acetic acid, it is a real constant.

Acetic Acid.		KCl		$K_4Fe(CN)_6$	
C	*K*	*C*	*K*	*C*	*K*
0.001	0.00177	0.0001	0.0075	0.0005	0.7
0.004	0.00180	0.001	0.065	0.002	18.0
0.01	0.00179	0.01	0.122	0.012	1171.0
0.02	0.00179	0.1	0.495	0.1	41190.0
0.1	0.00180	1.0	2.22	0.4	842100.0

This extraordinary divergence from the mass law, of which I have chosen the most extreme case known in aqueous solution, is, however, found to an even more startling degree in the case of non-aqueous solutions. To the extremely bizarre conductivity curves there obtained few have had the temerity to apply in full the principles derived from the ionic theory. Nevertheless, we are beginning to realize that the phenomena of aqueous solutions are but special instances of the widely varying phenomena occurring in other solvents; and it seems unlikely that a satisfactory understanding of the behavior of aqueous solutions can come except through a careful study of non-aqueous solutions. At present our quantitative knowledge of such solutions is extremely limited, and does not encourage the belief that we have in any sense a final answer to the problem of solutions.

These, then, are some of the weak points of the ionic theory as it stands to-day. If the case were to rest here I am afraid it would be difficult to bring in a verdict for the theory of dissociation. Indeed many scientists, on the basis of such evidence, have decided to close the hearing and to class the ionic theory with other ingenious hypotheses that have failed to stand the test of experience. But these men have not applied the one criterion by which in the end every scientific proposition must be judged—the test of serviceability. After all, what have we said except that the ionic theory is not complete? But perfection is rare in the science of chemistry. Our scientific theories do not, as a rule, spring full-armed from the brow of their creator. They are subject to slow and gradual growth, and we must candidly admit that the ionic theory in its growth has reached the "awkward age." Instead, however, of judging it according to the standard of perfection, let us simply ask what it has accomplished, and what it may accomplish in service.

When we examine a little more critically the unfavorable features which we have mentioned, we find that they enter chiefly in the application of the theory to strong electrolytes. If we consider the weak electrolytes, like ammonia, acetic acid, and most of the organic substances, of which a large number have been investigated, we find a remarkably satisfactory state of affairs. For these the mass law has generally been shown to hold with remarkable accuracy. Indeed it is hardly too much to say that every prediction from the ionic theory has been quantitatively verified for all the weak electrolytes which have been carefully investigated. The degrees of dissociation obtained in different ways are in complete accord; the properties are additive only just in so far as the electrolytes are ionized; the electrical properties seem entirely normal. Here, then, is an enormous field in which the whole theory of Arrhenius may be quantitatively applied, with perfect safety, to a wide variety of problems.

Again, in the case of strong electrolytes at high dilution, the theory of ionic dissociation is completely in accord with all known facts. The agreement between transference numbers measured directly and those calculated from the conductivities at infinite dilution is eminently satisfactory. There can hardly be any question that with increasing dilution the ratio of the molal concentration to that calculated when no dissociation is assumed approaches just two for binary, and just three for ternary salts. Is there any other hypothesis which will account for this cardinal fact?

Any valid criticism of the ionic theory must, therefore, be based upon its application to solutions of strong electrolytes at moderately high concentrations. Here the problem is unquestionably one of great difficulty. Even the simple question of determining the true degree of dissociation is one which still permits much divergence of opinion. One of the suggestions which has been made to account for some of the anomalies of the strong electrolytes is that, owing to the change in the mobility of the ions with the concentration, the conductivity is not a correct measure of the degree of dissociation. In some cases, especially in the case of the hydrogen ion, this supposition has indeed been definitely verified. Yet in the majority of cases it seems very unlikely that we may thus explain the extraordinary discrepancies such as those that I have pointed out in the application of the mass law to strong electrolytes. I have shown in another place that while conductivity may not indeed be an absolutely reliable measure of the concentration of the ions, it furnishes, nevertheless, the only way that we have of determining them. Every other method which has been used gives a measure, not of the real concentration, but rather of the escaping tendency, or activity, which may not in all cases be proportional to the concentration. I believe that we shall make no great error in assuming that the degree of dissociation calculated from the conductivities is in most cases substantially correct and that the lack of fulfillment of the requirements of the mass law for strong electrolytes is due to deviation of one or more of the dissolved substances from the laws of the perfect solution. This assumption is by no means inherently improbable. In fact, in the case of many non-electrolytes we find marked deviations from the ideal laws even at small concentrations.

If we must conclude that one of the substances present in a solution of an electrolyte is abnormal in its behavior, we are inclined at first to suspect the ions, which on account of their peculiar electrical condition might be expected to differ materially from ordinary substances. But this view proves to be untenable. As far as we can judge, the ions seem to obey, at least to a fair degree of approximation, the laws of the perfect solution, and thus we are forced to place the responsibility for the observed anomalies chiefly upon the undissociated part of the electrolyte.

The correctness of this idea may be tested by applying the simple laws of solutions to those cases where the properties of the undissociated substances may be eliminated from consideration. Every such test, which our present experimental material permits, substantiates this hypothesis. Thus, for example, when we consider the equilibrium between a dissolved salt and the ions in its saturated solution we need not consider the undissociated portion. Assuming that the ions are normal in behavior, we are led at once to the principle of the constancy of the solubility product, the substantial correctness of which has been demonstrated by the experiments of Noyes, and the more recent work of Stieglitz. An entirely similar method which depended upon the elimination of the undissociated electrolyte was employed by Rothmund in his study of the dissociation of picric acid.

Another deduction which is similarly justified is that the product of the hydrogen and hydroxide ion concentrations is a constant, in any dilute aqueous solution, and this important constant has been obtained by several independent methods, all in excellent agreement. Finally the Nernst equation for the electromotive force of a concentration cell gives very satisfactory results when we consider only the ion concentrations. If, however, we apply an equation similarly obtained to the undissociated portion of the electrolyte we obtain results which are by no means corroborated by experiment.

A few years ago I had occasion to make a calculation which involved simultaneously the application of all the principles which I have just enumerated, the Nernst equation, the solubility product, the dissociation constant of water. By the aid of these it was possible to calculate from the decomposition pressure of silver oxide the potential of the oxygen electrode. The potential thus obtained differed more than one-tenth of a volt from the value previously accepted, but was in perfect agreement with the results of the independent investigations published during the same year by Haber and by Nernst. The calculation would obviously have been vitiated if any one of the principles used had been unreliable.

To review the service rendered by these simple generalizations deduced from the ionic theory would be to summarize a very considerable part of the exact work in physical chemistry published during the past two decades. In the study of chemical equilibrium and reaction velocity, especially in the process of rationalizing quantitative analysis, these principles are of daily service.

While therefore many difficult problems relating to the application of the ionic theory remain to be solved, this theory must even at the present time be regarded as established on a sound working basis. Advance will come through the exact quantitative study of the properties of aqueous, and especially of non-aqueous, solutions. After this work is completed it is not improbable that our views of the nature of solutions will be greatly changed, but I venture to predict that the later and better theories will not be substitutes for, but rather developments of, the simple hypothesis of Arrhenius.

ENGINEERING NOTES.

It is universally admitted that coal dust is a greater menace in mines than fire damp, yet it is a fact that sufficient attention is not always paid to the prevention of its production and accumulation, and this can only be done by a proper system of mining and a constant and efficient cleaning of roadways. We find ample proof that it is the desire of almost every mine manager to repose comfortably under some form of watering the dust, generally the sprinkling system.

Rail failures in New York State, exclusive of New York city, totaled 1,829 in the four months from December, 1908, to March, 1909, inclusive, as against 3,917 for the same months in the previous year. The data furnished by fifty-four steam roads to the Public Service Commission of the Second District, show failures on thirty-two roads during the latter period, four causing accidents to freight, but none to passenger trains. Of the total failures seventy-five were in open-hearth rails.

Automatic block signals now stretch from the Atlantic to the Pacific Ocean, except for short distances aggregating a total of 127 miles, according to the Railroad Age Gazette. Of the distance unprotected by this system, 94.3 miles on the Southern Pacific, in the Sierra Nevada Mountains, use the electric train staff, and the next longest gap in the automatic system is 20 miles, due to a proposed change in line. The remaining distance is made up of four parts, on bridges and where changes are in progress. The line thus blocked runs from Jersey City on the east to Oakland, Cal., on the west, a total of 3,245 miles, including the Lehigh Valley Railway from Jersey City to Buffalo, the Lake Shore and Michigan Southern Railway to Chicago, and the Chicago & Northwestern Railway to Council Bluffs, the Union Pacific Railroad to Ogden, and the Southern Pacific to Oakland.

Discussion of the project of building street-railway subways in Chicago has directed attention to the fact that a United States patent was granted recently to Mr. George W. Jackson, constructing engineer of Chicago, for an "Underground Subway for Street Railways," etc. Mr. Jackson is reported to have said that his patent covers the most practicable way of building a subway under the conditions in Chicago, but other engineers believe that the essential features of a subway are not patentable, and that the granting of this particular patent, referring to a particular combination with public-utility service galleries, will not interfere with the city's plans. The patent in question is No. 922,768, and was issued May 25th, 1909. The application for it was filed on July 6th, 1908. The fourth claim, which seems to fairly indicate the scope of the patent, reads as follows: "A subway for traction purposes comprising a floor, sidewalls, and a roof, and posts supporting the roof from the floor and arranged in rows to divide the subway into centrally-located passages to receive car tracks, and two lateral passages having means for supporting therein public-utility appliances, and a horizontal or sub-roof between said car-track passages and the main roof, and said aisles being provided in line with said horizontal partition with horizontal supports, the whole dividing the upper part of the subway into a space through which is adapted to extend public-utility appliances of streets which intersect the subway, and into which are adapted to be carried or deflected certain of the public utilities carried in the lateral passages or aisles."—Electrical World.

A contributor to the Mechanical World mentions that he has tried chilled cast iron tools with considerable success when turning plain work. The shank of the tool was about ten inches long by two inches square, and the cutting portion was made of the ordinary round-nose shape, suitable clearance being provided, but no top rake employed. The required hardness of the tool nose was obtained by a chill-box. The molten metal which enters the chill-box is rapidly cooled, and when removed from the box the tool nose is extremely hard. All that is necessary is to grind it, and it is ready for use. A decided feature of its characteristics is its ability to cut cast iron which has been chilled through being poured into damp molds. Tools of this kind, it is stated, have, in a number of cases, saved partly machined work from being scrapped, when the best brands of high-speed steel were unequal to machining the cast iron. Tools of this type are handy to have around for occasional jobs which show themselves unamenable to ordinary methods. The use of chilled iron tools dates back many years. Its use at Lister's Works, Darlington, England, to turn chilled iron rolls, was mentioned in Moore's Guide, a heterogeneous collection of receipts and formulas for mechanics, grocers, lawyers, doctors, etc., published a long time ago. Some chilled rolls had been made so hard that carbon steel could not be used. One of the workmen suggested that if the chilled iron was harder than hardened steel, it might be found that a chilled iron tool might be made to cut, as it could be made as hard or harder than the roll. The suggestion was successfully followed.

ELECTRICAL NOTES.

Transfusion of particles of different kinds of metals through the agency of electrical current has been held by some to take place just the same as in the case of electrolytes, upon which action electroplating depends. To prove or disprove this contention an experiment was carried out on a product composed of aluminium and copper, firmly welded, through which an electrical current was passed continually for one year. After the two parts were separated it was found that neither metal contained any particles or traces of the other.

The tests that are in progress at Brant Rock, Mass., in connection with the project for erecting a 1,000-foot tower somewhere in the vicinity of Washington or Annapolis for a wireless telegraph station will not be concluded for several months yet, and the whole project depends on the result of these tests. It is not entirely settled that any advantage would follow from the use of a tower of such great height, and unless the instruments adopted in the undertaking demand it, the cost of erecting a 1,000-foot tower would be largely a waste.

For the city of Vienna there is a project being considered for securing a large amount of power for lighting and motor purposes, this to be had from a hydraulic plant lying at some distance off. According to the present plans, the new turbine plant is situated in the valley of the Enns. From the turbine station on the stream there will be run a power line about 90 miles in length, which will transmit the current to a sub-station located at Vienna. Only the main lines of the project are to be noted at present, and the details are to be drawn up at a later date. It is thought that the best plan in this case is to use the power of the Enns stream between Admont and Weissenbach upon a length of 24 miles by the use of a series of barrages distributed along the stream at intervals. It is estimated that the first expenses of the enterprise will reach $12,000,000. Should the project be carried out there will be enough power obtained to allow of using the current for operating the city railroad lines.

The possibility of determining by some means the whereabouts of the hidden treasures of the earth has long been an object of the miner's desire, the methods for accomplishing which range from the mediæval adept with his divining rod, belief in which is not wholly extinct to-day, down to a series of modern attempts to use electric currents for the same purpose. Up to the present these attempts have been unsuccessful, in spite of the ambitious claims of some of their advocates. In view of the fact that minerals differ so widely in their electric and magnetic properties, it is quite possible to conceive that some method of detecting concealed mineral deposits by these means may be devised. Indeed, for one particular class of minerals such a method has long been in existence; in Scandinavia there are many deposits of magnetite and many others of which magnetite forms a constituent, so that all such deposits distinctly affect a magnetic needle. The Swedish prospector has long used the so-called mining compass, which consists essentially of a small magnetic needle so suspended as to be able to move both horizontally and vertically. When this compass is brought over ground in which such deposits of magnetic mineral exist, the needle indicates their presence by its change of dip, so much so that it has been customary for years past in Sweden to buy and sell mineral properties by their "compass drag," or their effect on the miner's compass.

It will be remembered that Prof. Mercadier, of Paris, has been making experiments with his system of multiplex telegraphy on the tuning fork or resonator principle, using different sets of vibrations sent over the line at the same time, these being selected out at the receiving end by a number of resonating receivers. Up to the present, he carried this out by the use of two wires and without connection with the ground. He was thus able to send several telegrams at the same time which are formed by signals produced by alternating currents having different periods, using among others a printing telegraph which can be worked on these currents such as the Hughes printing telegraph. It will also be remembered that he was able at the same time to superpose upon these signals other signals produced by direct current which was given either by a Hughes apparatus, where the emissions have 1-28 second length, or from a Baudot apparatus in which the length is only 1-70 second. It was interesting from a scientific standpoint and also very important from a practical point of view to see whether the same results could be obtained upon a single wire and a ground, and this in spite of the natural earth currents and also the induction currents produced in the neighborhood of the two end stations of the line. The recent experiments were made on a line of 3 millimeters diameter and 300 miles length running between the central telegraph offices of Paris and Lyons. There were used on this occasion three Hughes apparatus working on alternating currents on one hand and on the other a Hughes apparatus or a Baudot telegraph with quadruple keyboard working on direct current. The experiments were very successful, and it was found possible to annul the effects of currents coming from the earth at the Lyons end of the line where they are especially strong, owing among other reasons to the heavy currents of the city tramway lines. The messages could be sent in about the same way as when a double line was used, so that the system has made a considerable advance from a practical standpoint.

TRADE NOTES AND FORMULÆ.

Greasing Medium for Wool to Be Spun (French).—12 parts by weight of dissolved Marseilles soap, 50 parts of olein, and 50 parts of olive oil. Of this mixture, 12 to 15 parts suffice for 100 parts by weight of fine or coarse wools.

Unboiled Varnish (metal varnish).—According to Weger the siccative (resinate of manganese, linoleate of manganese, resinate of lead-manganese, linoleate of lead-manganese, bichromate of lead, etc.) in the oil is heated to about 248 deg. F. or at most 327 deg. F. and expedite the solution by continuous stirring, or proceed by dissolving 1 part of the siccative in 2 parts of linseed oil, heated to 248 deg. F. and then adding this solution to 50 to 100 parts of linseed oil, likewise heated to 248 deg. F.

Macrone's Varnish.—This varnish is used as a coating for paper hangings before the application of dry colors, to impart brilliance to them and make them washable. Secondly, it serves as a substitute for lithographic ink, or to supplement the latter; and thirdly, to render paper and fabrics waterproof. The varnish consists of 72 parts non-odorous seed oil, 32 parts rosin, 16 parts paraffine, 4 parts beeswax, 1 part copal varnish. The seed oil is heated until foaming ceases, and then the rosin, paraffine, wax, and copal varnish added in the stated quantities. The varnish is usually used cold, but to waterproof paper, etc., it should be heated to 212 deg. F.

Carborundum (silicium carbide) is an abrasive material, obtained by heating clean sand, coke, and salt in an electrical furnace. To make sharpening stones, wheels, etc., that require a hard binding material (e. g., porcelain salt), carborundum of the desired fineness is incorporated, by hand, with a suitable binding material, the mass is placed in molds and subjected, by means of hydraulic presses, to a pressure varying from 1 to 100 tons for the different articles. The articles, after being taken from the press, are placed in porous clay receptacles, which are exposed in a reverberatory furnace to rising flame. The furnace is then sealed up and the burning continued at gradually increasing temperature. The firing continues for about thirty hours. The heat is carried almost to the fusion point of the binding agent and is controlled by taking samples. As soon as the binding agent begins to melt the rise in temperature is stopped. The entire process takes from 60 to 80 hours. The wheels, etc., are of a clear, green color, extremely hard, and compared with corundum wheels, are said to accomplish, in a given time, three to four times as much work.

Fruit Syrup.—According to Kuhn, use a steam generator, a steam boiler with basket and inserted strainer, a separable stirring apparatus, and a container for boiling water, which at the end of one using serves for the cleaning of the kettle. The kettle being fitted with basket and filter, 4 pounds of sugar syrup are brought to a boil in it, then introduce, for instance, 4 pounds of fresh strawberries, allow it to come to a boil once, and then to draw long enough for the fruit to part with all its juice to the sugar syrup, so that the color, delicate flavor, and sharpness are contained in it; then draw the basket up, allow the shrunken residue of the fruit to drain, run the finished syrup out of the kettle, and when bottled it will be ready for shipment and consumption. The residue of the fruit, at the close of the day's work, should be boiled down with an equal quantity of fresh fruit, in this case 4 pounds, to make marmalade, for which purpose the stirring apparatus is to be used. Results of the process: 20 pounds fresh fruit yield about 16 pounds of juice; 20 pounds of sugar syrup with 20 pounds of strawberries and all other kinds of berry fruits, 3.6 pounds of fruit syrup.

TABLE OF CONTENTS